UNIVERSITY OF NOTTINGHAM

REPORT OF THE SCHOOL OF AGRICULTURE

1957

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UNIVERSITY OF NOTTINGHAM SCHOOL OF AGRICULTURE.

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1957

SUTTON BONINGTON
LOUGHBOROUGH
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1958

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INTRODUCTION.

THE UNIVERSITY OF NOTTINGHAM SCHOOL OF AGRICULTURE

THE School of Agriculture in its present form came into being in 1947, with the transfer to University College, Nottingham, of the buildings and land formerly held by the Midland Agricultural College. It is situated at Sutton Bonington, eleven miles from the University centre, and houses the four University departments of Agriculture, Agricultural Sciences, Horticulture and Agricultural Economics, and also the Veterinary Investigation Centre of the East Midlands Province.

The estate lies in rolling country in the valley of the River Soar, ten miles south of the city of Nottingham. It consists of about 500 acres of land, lying between 100 and 250 feet above sea level, some 300 acres of which are arable. The estate also includes a modern fruit plantation, a market garden, three-quarters of an acre of horticultural glasshouses and one-quarter of an acre of Dutch lights, together with ornamental and sports grounds. At the time of the transfer, the buildings held by the Midland Agricultural College consisted of a central block, including administrative offices, library, lecture rooms and teaching laboratories for chemistry and biology, the dairy and an adjacent house, "The Elms", that had been converted to offices and research laboratories.

The former college had its beginnings in the Department of Agriculture of University College, Nottingham (founded in 1893) and in the Midland Dairy Institute (founded in 1895), which were combined to form the Midland Agricultural and Dairy Institute in 1900. In 1906 the title was changed to College, but for the first thirty years of its existence the main emphasis of its work remained the provision of certificate and diploma courses in Agriculture, Dairying and Poultry Husbandry. In 1942 a Horticultural Department was added, and in 1943 collaboration between the Midland Agricultural College and the University College led to the establishment of the Faculty of Agriculture and Horticulture, which was followed four years later by the transfer of the college to the University College authorities in 1947.

The Chair in Agriculture was created in 1943 when H. G. Robinson, then Principal of the College, became the first Professor of Agriculture.

Since 1947, in conformity with the recommendations of the Loveday Report, the diploma courses, with one exception, and the certificate courses have been terminated. The Diploma course in Agriculture was terminated in 1950, that in Horticulture in 1954 and that in Poultry Husbandry in 1955, and in 1957 the intake for the Diploma course in Dairying was reduced to sixteen. During the past ten years the staff and facilities for degree and post-graduate teaching have been steadily built up and two new Chairs created, Agricultural Chemistry in 1949 and Agricultural Botany in 1953.

Because of the building difficulties of the post-war period, it has only now become possible to expand the permanent laboratory blocks in the manner originally anticipated, but considerable expansion into temporary buildings and conversion of existing ones have taken place. In 1952 the University took over St. Michael's House, situated on the boundary of the property, and adapted it as the Deptpartment of Agricultural Economics, whilst "The Elms" has been developed to house the Veterinary Investigation Centre for the East Midlands and the research laboratories of the Agricultural Zoology and Animal Physiology sections. Since then, in addition to the temporary laboratories, a milk-products laboratory has been built in the Dairy, small-scale plant growth rooms have been built for the Departments of Horticulture and Agricultural Sciences and a new range of glasshouses built for experimental work. The glasshouses include three designed for general work on plant nutrition and plant physiology and one fly-proof glasshouse for entomology.

In April, 1957, work was commenced on the construction of a new building to house teaching and research laboratories for the Chemistry and Botany sections of the Department of Agricultural Sciences and for the Crop Husbandry and Animal Physiology sections of the Department of Agriculture. It is hoped that this building, which will greatly improve the laboratory accommodation of the School, will be in full use for the commencement of the 1959-60 session.

One of the farms held by the University, Lodge Farm, consisting of some 150 acres, was adapted in 1954 as a field experimentation unit and equipped for work in various aspects of crop and animal husbandry. It includes a slaughterhouse and cold room, small animal houses, a metabolism room, a field laboratory, rooms for the use of radio-active isotopes and a range of feeding pens. The object of this unit is to provide facilities for research for all sections of the Agriculture and Agricultural Sciences Departments. Facilities are also provided for a crop testing station of the National Institute of Agricultural Botany and an extensive series of potato variety demon-

stration plots for the Ministry of Agriculture, Fisheries and Food. The livestock are maintained solely for the purposes of research and comprise a dairy herd of identical twin cows and heifers, a number of pairs of twin steers, a flock of Kerry and Clun ewes and colonies of rabbits and rats which are used for assay and preliminary experimentation. A herd of Large White Pigs was established in 1955 and in 1956 a new piggery designed to allow individual feeding was erected. A fully equipped Engineering Workshop is available for the practical demonstration of aspects of farm mechanisation and is also used to maintain all the mechanical equipment of the School.

Some 350 acres, based on the Manor Farm, Kingston, is run as a commercial farm with a completely separate labour force, and is used to demonstrate the techniques of farm management appropriate to the district.

The objectives of the School are twofold, to enlarge the stock of knowledge relating to Agriculture in its widest sense, and to disseminate it by means of undergraduate and post-graduate courses. The University of Nottingham maintains at the School courses of instruction for the degree of B.Sc. and candidates admitted to such courses may qualify for honours degrees in Agriculture, Agricultural Botany, Agricultural Chemistry, Agricultural Microbiology, Agricultural Zoology or Horticulture, or for pass degrees in Agriculture, Dairying or Horticulture. A course is also given leading to a diploma in Dairying. Enrolment for the current year included 142 students for first degree courses, 34 students for the diploma course and 18 students for post-graduate courses.

The Department of Agricultural Economics is a part of the Provincial Agricultural Economics Service for England and Wales, and is responsible to the Ministry of Agriculture, Fisheries and Food for the supply of economic data about agriculture in the East Midlands. It is at the same time responsible for advisory and extension work in agricultural economics and farm management throughout the East Midlands Province.

Apart from the work of this one department, extension work in agriculture is not a function of the School, although some is effected through visits of Young Farmers' Clubs, parties of farmers and other visitors to the experimental and demonstration fields and to the laboratories, and by lectures given by members of the staff to farmers' and growers' organisations. During the period under review members of staff have co-operated with the British Broadcasting Corporation in giving talks on the Sound and Television services.

The scientific work of the School centres around the study of the principles of crop and animal husbandry, and of the problems which may be associated with them. Expressed in more precise terms the aim is to conduct researches on soil, plant and animal problems relating to agriculture and horticulture and on the insect pests which affect production. Certain aspects of the work in progress, which has reached a stage suitable for review, are described in a later part of this report.

This research work is mainly financed from general University funds but in recent years investigations have been aided by grants from other organisations. In 1957 the Department of Horticulture received a concluding grant of £550 from the Agricultural Research Council for work, which the Council has supported since 1953, on the water relationships of plants grown under glass and various aspects of the regeneration of plants from roots. The Department has also received grants totalling £733 from the Agricultural Research Council to enable an investigation to be started on the diagnosis of damage to horticultural crops by drift of hormone weed killers and also to assist in a joint investigation into root excretions. In the Department of Agricultural Sciences the Fison Research Fellowship for work in soil science and plant nutrition, established in 1955 by Messrs. Fisons Limited, will be continued until 1958 and a new Fellowship, the African Pyrethrum Fellowship, for the study of certain problems related to the use of pyrethrum as an insecticide on field and horticultural crops was established in 1957 by the Pyrethrum Board of Kenya. During the year appointments were made to the senior and junior Leverhulme Fellowships financed by the Trustees of the Leverhulme Trust Fund for investigational work on the mode of action of hormones in promoting improved growth rate in animals.

The Department of Agricultural Economics has received a grant of £3,000 from the Ministry of Agriculture, Fisheries and Food for an enquiry into the economics of farm buildings and also a gift of £300 from Messrs. W. Parker and Sons. Messrs. Boots Limited continue to support the work of the School and in 1957 donated a total of £535 for use in hormone studies. Messrs. Fisons Limited have given £2,000 spread over a period of three years for investigations by the Departments of Agriculture and Agricultural Economics into the implications of the intensification of grassland production for beef cattle. With the advice and co-operation of the East Midlands Electricity Board the facilities of the Experimental Farm have been greatly improved by the installation of additional grain drying and handling equipment and by rewiring part of the premises. This

reorganisation of the granary was materially assisted by a contribution from the Crittall Manufacturing Company towards the cost of the grain storage bins. The British Oil and Cake Mills Limited have continued to contribute to the success of the experimental work on livestock with several gifts of feeding stuffs, and valuable assistance has been obtained from Messrs. J. Sainsbury Limited with pig carcase dissections. Gratitude is expressed to the numerous farmers in the East Midlands who have kindly given facilities for experimental work with livestock and in particular to Mr. J. F. D. Hargreaves of Goxhill for his gift of sheep to the Experimental Farm. Contributions towards the cost of construction of the new animal house to accommodate small experimental animals have been received from the following firms—F. E. Stevens, R. and W. Paul, Spillers, Joseph Rank, Bibby and Sons and Pfizers.

To all the above firms and organisations and to the many other firms, such as British Drug Houses Limited and Imperial Chemical Industries Limited, who have generously provided assistance in the form of supplies and equipment, feeding stuffs, hormones, antibiotics and other drugs, grateful acknowledgment is made.

THE UNIVERSITY OF NOTTINGHAM

Chancellor :
His Grace the Duke of Portland, K.G., LL.D.

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Deputy Vice-Chancellor :
Professor Ernest James William Barrington, M.A., D.Sc.

Registrar :
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SCHOOL OF AGRICULTURE

STAFF

Dean of the Faculty of Agriculture and Horticulture :
Professor E. G. Hallsworth, B.Sc., Ph.D. (Leeds), A.R.I.C.

DEPARTMENT OF AGRICULTURAL SCIENCES

Professor of Agricultural Chemistry and Head of Department :	E. G. Hallsworth, B.Sc., Ph.D. (Leeds), A.R.I.C.
Agricultural Chemistry :	
Lecturers :	
Soil Chemistry	D. V. Crawford, M.A., B.Sc., (Oxford)
Dairy Chemistry	E. R. Ling, M.Sc., (London), Ph.D. (Nottingham), A.R.C.S., F.R.I.C.
Bio-chemistry	*H. A. Robertson, B.Sc., Ph.D. (Edinburgh), A.R.I.C.
Analyst :	*A. C. Burns, M.Sc. (Manchester) F.R.I.C.
Assistant Lecturer : (Temporary)	
Bio-chemistry	A. A. Wright, M.A. (Cambridge)
Fison Research Fellow :	I. H. Rorison, M.A., D.Phil. (Oxford)
Demonstrator :	A. L. Lakin, B.Sc. (Reading)
Research Assistant :	E. A. N. Greenwood, B.Agr. Sci. (Melbourne), D.D.A.
Agricultural Botany :	
Professor :	F. L. Milthorpe, M.Sc. Agr. (Sydney) Ph.D. (London), D.I.C.
Lecturers :	
Agricultural Botany	K. W. Dent, B.Sc., Ph.D. (Birmingham) Miriam M. Edwards, M.Sc., Ph.D. (Manchester)
Plant Pathology	T. H. Nicolson, B.Sc. (Agric.) (Aberdeen), Ph.D. (Nottingham)
Genetics	W. J. Whittington, B.Sc. (Wales), Ph.D. (Nottingham)

*Resigned September, 1957.

Demonstrator :	P. Newton, B.Sc. (Nottingham)
Agricultural Microbiology :	
Senior Lecturer :	M. Woodbine, M.Sc., Ph.D. (Manchester) F.R.I.C.
Lecturer :	A. Seaman, B.Sc. (London) Ph.D. (Nottingham)
Demonstrator :	Kathleen N. Smith, B.Sc. (Edinburgh)
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Assistant Lecturer :	J. Y. Ritchie, B.Sc. (Agric.) (Glasgow)
Demonstrator :	S. K. Bannerjee, B.Sc. (Calcutta)
Dairying :	
Lecturer and Head of Sub-Department :	R. Scott, B.Sc. (Agric.) (Nottingham), N.D.A., N.D.D.
Lecturer :	M. Stein, J.U. Dr. (Prague), B.Sc., Ph.D. (Leeds)
Assistant Lecturer :	Eunice W. Whitt, B.Sc. (Reading)
Departmental Assistants :	Maud Arnot, N.D.A., S.D.A., S.[illegible].D.
	*Anne C. Hall, N.D.D.

DEPARTMENT OF AGRICULTURE

Lecturer in Crop Husbandry and Acting Head of Department :	J. D. Ivins, B.Sc. (Reading), M.Sc. (Agric), Ph.D. (Nottingham)
Lecturers :	
Agricultural Engineering :	J. Chatterton, D.F.C., B.Sc. (London), M.Sc. (Nottingham)
Animal Physiology	G. E. Lamming, B.Sc. (London) M.S., Ph.D. (Illinois), N.D.A. (Hons.)
Animal Husbandry	J. T. Morgan, M.Sc. (Wales), Ph.D. (Nottingham), A.R.I.C.
Part time Lecturers :	
Book-keeping	H. Harris, B.Sc. (Econ.), D.P.A. (London), F.C.C.S.
Building Construction	G. Wheatley.

*Resigned October, 1957.

Honorary Lecturers :	
Veterinary Hygiene	J. C. Buxton, B.Sc., Ph.D. (Nottingham), M.R.C.V.S.
	Connie M. Ford, M.R.C.V.S.
Assistant Lecturers :	
Crop Husbandry	Jean Dilnot, B.Sc. (Wales)
Animal Husbandry	F. R. Green, B.A., Dip. Agric. (Cambridge)
Leverhulme Research Fellows :	
Senior	E. M. Martin, M.Sc. (Melbourne)
Junior	W. R. Shorthose, B.Sc. (Nottingham)
Demonstrator :	R. A. Costain, B.Sc. (Nottingham)
Superintendent of Potato Trials :	Nora McDermott, M.B.E., M.Sc. (Agric.) (Nottingham)
Regional Trials Officer (National Institute of Agricultural Botany)	T. Webster, B.Sc., (Agric.) (Glasgow) M.Sc. (Nottingham), Dip. Agric. Science (Aberystwyth), N.D.A.

DEPARTMENT OF HORTICULTURE.

Professor of Horticulture and Head of Department :	J. P. Hudson, M.B.E., G.M., B.Sc. (Hort.), M.Sc. (London), Ph.D. (Nottingham), N.D.H.
Lecturers :	Margaret E. Marston, B.Sc. (London), M.Sc. (Hort.) (Nottingham), N.D.H.
	W. Heydecker, B.Sc. (Hort.) (Reading), M.Sc. (Nottingham), N.D.H. (Hons.)
	Winifred M. Dullforce, M.Sc. (Nottingham), N.D.H.
Demonstrator :	*I. H. Williams, B.Sc. (Hort.), M.Sc., Ph.D. (Nottingham)
Research Assistants † *:*	*J. A. Mackenzie, B.Sc. (Nottingham)
	J. G. Davison, B.Sc. (Nottingham)

*Resigned, September, 1957.

†Financed by the Agricultural Research Council.

DEPARTMENT OF AGRICULTURAL ECONOMICS.

Senior Lecturer and Provincial Agricultural Economist :	K. Rasmussen, Cand. polit. (Copenhagen)
Senior Agricultural Economists :	R. B. Jones, M.Sc. (Wales)
	E. Mejer, M.Sc. (Vilno), M.Sc. (Agric.) (Nottingham)
	W. S. Senior, B.Sc. (Agric.) (Leeds)
Agricultural Economists :	R. O. Wood, M.Sc. (London)
	K. A. Ingersent, B.Sc. (Aberdeen), M.S. (Minnesota)
	R. G. Mortimer, B.Sc. (Wales)
Assistant Agricultural Economists :	R. W. T. Hunt, B.Com. (Liverpool)
	Margaret M. Sandilands, B.A. (London)
	T. W. D. Theophilus, B.Sc. (Wales)
	*A. Brown, B.Sc. (Nottingham)
	D. P. Baron, B.A. (Econ.) (Manchester)
	T. K. Warley, B.Sc. (Hort), M.Sc. Nottingham)

OFFICERS OF THE SCHOOL OF AGRICULTURE

Secretary to the School of Agriculture :	H. Harris, B.Sc. (Econ.), D.P.A. (London), F.C.C.S.
Senior Tutor :	J. T. Morgan, M.Sc. (Wales), Ph.D. (Nottingham), A.R.I.C.
Librarian :	Nancy W. Rhodes, B.A. (London), A.L.A.
Surveyor :	G. Wheatley.
Farm Manager :	A. C. Thompson.
Horticulture Manager :	F. C. Johnson, B.Sc. (Agric.) (Edinburgh)
Executive Assistant :	Muriel I. Wood.
Chief Technician :	F. C. Treeby.

*Resigned September, 1957.

POST-GRADUATE STUDENTS

	Subject	Degree
N. Ahmad, M.Sc. (Brit. Columbia), A.I.C.T.A. (Trinidad)	*Agricultural Chemistry*	Ph.D.
D. M. Allen, B.Sc. (Reading)	*Animal Physiology*	Ph.D.
D. Aspinall, B.Sc. (Nottingham)	*Agricultural Botany*	Ph.D.
M. N. Borah, M.Sc. (Agric.) (Banaras Hindu)	*Agricultural Botany*	Ph.D.
A. W. J. Broome, B.Sc. (Nottingham)	*Animal Physiology*	Ph.D.
D. W. T. Clay, B.Sc. (Nottingham)	*Horticulture*	M.Sc.
W. F. Coulson, B.Sc. (Nottingham)	*Agricultural Chemistry*	Ph.D.
B. N. K. Davis, B.Sc. (Aberdeen)	*Agricultural Zoology*	M.Sc.
J. Davison, B.Sc. (Durham)	*Crop Husbandry*	Ph.D.
T. K. Fahmy, B.Sc. (Agric.), M.Sc. (Dairying) (Cairo)	*Agricultural Microbiology*	Ph.D.
C. P. Freeman, B.Sc. (Birmingham)	*Agricultural Chemistry*	Ph.D.
D. W. R. Headford, B.Sc. (Nottingham)	*Agricultural Botany*	Ph.D.
R. B. Heap, B.Sc. (Nottingham)	*Animal Physiology*	Ph.D.
J. S. M. Hutchinson, B.Sc. (Nottingham), Dip. Agric. Sc. (Cambridge)	*Agricultural Chemistry*	Ph.D.
E. J. M. Kirby, B.Sc. (Durham)	*Agricultural Botany*	Ph.D.
G. Norton, B.Sc. (Nottingham)	*Agricultural Chemistry*	Ph.D.
A. Panizai, B.Sc. (Ag.), (Punjab)	*Agricultural Zoology*	M.Sc.
L. B. Smith, B.Sc. (McMaster), M.S.A. (Toronto)	*Agricultural Zoology*	Ph.D.
C. D. Sutton, B.Sc. (Nottingham)	*Agricultural Chemistry*	Ph.D.
P. Wix, B.Sc. (Nottingham)	*Agricultural Microbiology*	Ph.D.

THE WORK OF THE SCHOOL OF AGRICULTURE

The problems under investigation fall into several groups which can be enumerated briefly as :

(a) Soil topics—investigations into the nature and distribution of soils and of the processes responsible for their formation.

(b) Factors affecting plant growth—the weather, water relations, mineral nutrition, cultural practices, weed competition, etc.

(c) Factors affecting animal growth and reproduction—nutrition, the level and effect of different hormones.

(d) Problems connected with the effect of insects and other invertebrates.

(e) Microbiological problems affecting either plant or aninal health, or concerning the utilisation of agricultural products.

(f) Farm management and returns in relation to the national economy.

The investigations in progress in each of the fields are reported briefly below, and more complete accounts of certain topics are given later.

Soil Studies.

Studies have continued of the mobilization of iron in the soil and its subsequent deposition elsewhere in the profile. The application of spectrographic techniques has shown that besides iron and aluminium a variety of elements may be mobilized in incubating soil. Although for several elements the amount coming into solution may be of biological significance, particular interest attaches to the observation that silicon comes into solution in appreciable quantities. Dialysis of extracts from incubated soils has shown that most of the iron is in colloidal form rather than in the form of soluble complexes.

The study of the nature of the ironstone concretions found in the soils of the University farms, and of the conditions governing their occurrence has been completed and an account is given later in this report. A chemical and mineralogical examination of two laterite profiles has been made, and shows a marked fall in the iron content of the horizons beneath the iron pan, which suggests that iron mobilization in laterites, as in the soils of the University farm, is greatly influenced by the presence of a water saturated zone in the profile.

A survey has been commenced of the soils of the University farms, and mapping of the distribution of most of the upland soils has now been completed.

Advantage has been taken of the presence of large areas of virtually sterile overburden from the open-cast ironstone workings in Northamptonshire to study the effect of the inoculation of earthworms on soil structure and fertility. Over the last two years, in co-operation with the company concerned with extraction of the ironstone, experimental plots have been laid down to which earthworms have been added at various rates from 0 to 600,000 worms per acre. In the original plots a mixed culture of four of the commonest species has been used. These included two of the deep-living surface casting species *Allolobophora longa* and *Lumbricus terrestris*, and two of the smaller surface living species *A.caliginosa* and *A.chlorotica*. The plots, which were on a freshly established lucerne, white clover, cocksfoot pasture, all received a dressing of farmyard manure equivalent to 10 tons/acre. The results have been followed by visual observations and by measuring the herbage produced. Inoculation at the heaviest rate used (600,000/acre) has given the greatest yield of forage, but so far the differences are not significant. Observations will be continued over the next two years.

Factors affecting plant growth.

Studies of the mineral nutrition of legumes in the Agricultural Botany and Agricultural Chemistry sections have been continued, and a new approach to the understanding of the effects of certain deficiencies has been made by considering the changes occurring within the first few days of the onset of the deficiency. At present only boron and iron have been considered in this way.

The influence of boron deficiency on radicles of field bean during the first four days of treatment has been studied. Estimations of dry weight, respiration rate, cell volume, nitrogen, sugar and desoxyribose nucleic acid were made per cell in successive zones of the apical 1 cm of radicle. Boron deficiency was found to result in lowered respiration rate and sugar content, but increased dry weight, volume and nucleic acid content. This investigation of the physiological role of boron is continuing.

Iron deficiency in the lupin has been found to result in a large increase in the soluble amino-acid concentation. Asparagine appeared to be most affected, but considerable increases in aspartic acid, serine, glycine alanine and y-amino-n-butyric acid were shown. In addition to the increases in amino-acids, the hydroxy-acid pattern was also

disturbed, as more citric but less malic acid appeared to be present. It would appear that iron deficiency in the lupin not only affects chlorophyll synthesis and hence, indirectly, photosynthesis, but also that the activity (or perhaps quantity) of certain iron-containing enzymes is reduced. In this case it seems likely that the cytochrome-cytochrome oxidase system of the first reducing process of the tri-carboxylic acid cycle ceases to function properly. This would have the direct result of increasing citric acid and certain amino-acids associated with the cycle.

A necrosis of the older leaves of subterranean clover grown in sand culture has shown to be related to high levels of available phosphorus in the nutrient medium. The critical characteristics of this disorder, which has been termed phosphorus toxicity, in relation to the copper, calcium and nitrogen supply have been studied by both chemical analysis and glasshouse experiment. A positive direct effect of copper in stimulating both nitrogen fixation and the uptake of phosphorus by the plant has been shown. The effect of phosphorus in enhancing the uptake of molybdenum reported originally elsewhere, has been confirmed. The effect of copper has been extended to cover a wider range of levels of supply, and to include white clover (S.100). A relationship between copper supply and the development of flowers heads has been observed, whilst S.100 also appears to be sensitive to phosphorus toxicity.

The maximum radius of the rosette has been found to be of considerable value as a growth index for subterranean clover which is particularly sensitive during the first four months of growth.

Investigations of the effect of the components of the soil acidity complex have been continued and a further account of the effects of aluminium are given later in this report. It has been shown that the effects of acidity as such are important, and a low acidity may result in reduced growth even where no toxic symptoms are visible. It appears that this restrictive effect can be largely mediated by increase in the level of supply of calcium and nitrogen. Part of the effect of acidity in soils is due to the increased availability of aluminium and manganese, but whereas the influence of aluminium appears to be largely through its effect in restricting root growth, manganese is absorbed by the plant and presumably interferes with some enzyme system. The amount of manganese actually absorbed varies both with the calcium supply and with the light intensity, and under conditions of high light intensity greater amounts of manganese are absorbed by the plant. The results of this work are being published elsewhere.

Investigations on the rate of development of the leaf surface of plants have been continued in the Agricultural Botany section. A considerable mass of data involving the effects of temperature, light intensity and length of day on leaf development of the cucumber has been accumulated and is now being analysed. This will be reported in detail during the coming year, particular emphasis being given to the physiological processes influenced by these factors and to the degree of dependence of leaf growth on assimilation.

Work on the physiology of growth of the potato plant has been commenced; the main emphasis being given to tuber formation and development and to the growth of buds during the chitting period. Data on the effect of temperature, light intensity and day length on tuber formation and growth are being collated and further experiments on this theme under constant conditions are in progress. A series of experiments to investigate the changes in bud development which occur during chitting and the influence of bud size and development at planting on subsequent growth has been commenced. These will be related to the effect of maturity of seed tubers at harvest on their yield in the following season. Preliminary work in sterile culture has shown that tuber formation occurs in both light and darkness and is influenced greatly by the sugar concentration of the medium.

Arising out of previous work on the agronomy of the potato crop regarding water relationships, depth of planting and cultivations, the Crop Husbandry section are investigating a new method of potato planting. The crop is planted in a slight depression rather than in the traditional ridge, and subsequent cultivations are shallow and merely destroy weeds and build soil around the potato plant. The results of this trial in 1957 have been encouraging.

The 'saleability' of potatoes is often greatly reduced by the disease Common Scab (*Streptomyces scabies*). Despite many efforts, control of this disease is still very limited. The disease is greatly influenced by soil conditions, particularly texture, pH and humus content. One recommended control measure is to incorporate fresh organic matter (such as a green crop) into the soil prior to growing a potato crop. Control obtained in this way has been attributed to the stimulation of micro-organisms which are antagonistic to the scab organisms; however, much confusion exists regarding this matter. Work has been initiated to study the mechanism of control by organic matter application and to select and test organisms for antagonism against *S.scabies* with a view to using these for control under experimental conditions.

Trials have continued on the effects and interactions of seed rate and fertiliser usage on the yields of barley. The results of this investigation are recorded elsewhere in this report. The produce of various treatments being of varying nitrogen content, is being used in pig feeding trials and metabolism studies in order to ascertain the feeding value of nitrogen in the grain.

Further study of the causal factor of dormancy in charlock seeds has shown that the slow rate of diffusion of oxygen through the testa, combined with its respiratory activity, limits the availability of oxygen to the embryo. Charlock seeds probably contain a number of inhibiting substances some of which can be extracted from the dry seed and are unrelated to growth. When water is absorbed there is continuous production of an inhibitor by the embryo at low oxygen levels. Growth of the radicle is proportional to the amount of inhibitor produced ; dormancy may possibly be attributed to the time required for the breakdown of the testa barrier to oxygen and the exhaustion of the source of inhibitor production.

One phase of the investigation in the competition between *Polygonum lapathifolium* and barley has been completed and is reported elsewhere in this issue. Evidence was obtained which suggests that the marked reduction in growth rate of the individual plants which always occurs at high densities (rates of seeding) was due partly to restriction of root growth and the consequent decrease in amount of nutrient absorbed. These smaller plants, therefore, are not only a result of decreased assimilation following mutual shading.

Investigations have been continued on the effect on the growth of cereal roots of the synthetic weed killers, 2, 4 : dichlorophenoxyacetic acid and methylchlorophenoxyacetic acid. These have involved growing the roots in solution of the herbicide for varying lengths of time and at different concentrations.

The importance of being able to control the environment more closely becomes increasingly obvious, and the effects of random changes of the environment on the development of both toxicity and deficiency symptoms in the legumes have already been mentioned. Plant growth rooms in which temperature, light and length of day can be controlled have been set up in two departments of the School and are being used to full capacity. In the Department of Horticulture, growth rooms have been used in a study of the factors which affect the seasonal behaviour of raspberry and other plants, and it is now possible to take raspberry shoots through the normal two-year cycle in as little as six months, and to produce any phase of growth at will.

In the same department, work on the soil-moisture relationships of plants has passed from a study of soil moisture tension to the effects of the osmotic pressure of the soil solution. Tomato and lettuce plants are being grown in beds of soil maintained at constantly low moisture tensions but salinised to different levels of salt concentration, using potassium, magnesium and calcium sulphates as the main salinising agents. It is becoming evident that tomato plants can produce reasonable yields under surprisingly saline conditions, if moisture tension is prevented from rising above a low level. Work also continues on the factors affecting germination and seedling emergence in the field and under laboratory conditions ; the behaviour of severed leaves, with particular reference to the processes involved in the regeneration of roots and shoots ; the factors affecting the recovery of young plants from the check of transplanting ; and the effects of temperature and light on the growth and development of lettuce plants. New growth rooms have been installed to facilitate the work.

Investigation of a case of sterility in red clover has shown it to be due to failure of the chromosomes to pair during division (asynapsis) followed by the formation of many degenerate pollen grains in each spore mother cell. The effect of environmental treatments on this abnormal condition are being studied.

Vesicular-arbuscular mycorrhiza are widespread in members of the Gramineae (cf. Annual Report for 1956) but so far there is little direct evidence regarding its significiance. Studies are continuing in grasses with regard to the distribution and intensity of infection and of external mycelium in different grasses in different ecological habitats and communities ; the assessment of host-endophyte relations by direct observation and experiment ; and on the nature of vesicular-arbuscular endophytes and other fungi infecting grass roots.

Factors affecting animal growth and production.

The investigations on grassland in the Crop Husbandry section have continued along the lines described last year, but in addition use has been made of beef cattle and sheep under controlled grazing in an attempt to evaluate pasture production more accurately. Identical twin dairy cattle have again been used to measure grassland production and its influence on milk composition (the latter in co-operation with the Dairy section). Indoor feeding trials with cut herbage have been carried out to ascertain with greater precision than is possible in the field, the relationship between herbage consumption and utilisation by the dairy cow. This information is not only of

fundamental importance to the interpretation of the results of grassland evaluation, but may also have some immediate value to farmers interested in the relatively new technique of zero-grazing. Similarly the relationship between consumption and utilization of herbage by beef cattle has been studied in order to provide information on the economics of intensive grass production for beef cattle.

Studies in the Animal Husbandry Section on factors affecting the growth of the bacon pig have continued. Using the individual feed house the effects and interactions of protein levels, antibiotics and hormone treatment on the growth rate and carcase quality of bacon pigs are being investigated and complete analysis of the carcases is being undertaken. Further work has proceeded on the nutritional factors affecting foetal growth and development.

In co-operation with the Agricultural Chemistry section, a long-term experiment is being made on the effect of various levels of roughage feeding during rearing on the ability of the dairy cow to utilise roughage for milk production. Use is being made of identical twin dairy heifers for this work. The first group of animals have recently calved and further groups are in the rearing stage. Preliminary results from animals already slaughtered have shown a marked difference in the nature of the stomach lining between the high and low-fibre groups.

At the same time attempts are being made to improve the analytical procedures available at present for characterising the fibrous and carbohydrate constituents of animal feeds, and a preliminary enzyme treatment has been developed which gives an unaltered fibre fraction of lower protein content than has previously been obtainable.

The study of the effect of oestrogenic hormones and their analogues on growth rate and carcase quality has been greatly expanded. The facilities provided for this extended study by co-operating farmers are greatly appreciated. The husbandry aspects of dosage and feeding, using hexoestrol and stilboestrol, are being investigated in addition to the physiological implications. This work has aroused considerable interest, and the early results were recorded in the 1956 report of the School of Agriculture. It has been necessary to extend the slaughterhouse to deal with the increased number of animals under experiments, and in 1957 some 700 sheep and cattle were slaughtered.

An investigation has commenced into the effects of nutrition on the reproduction of the ewe and work continues on the effect of ovarian hormones on the resistance to uterine and general infections. A

spectrographic method for studying the composition of small amounts of uterine secretions has been developed.

Work on the estimation of the follicle stimulating hormone (F.S.H.) and the interstitial-cell-stimulating hormone (I.C.S.H.) content of sheep pituitaries continued for most of the year but this, together with the study of histological and cytological changes in the thyroid glands, is now being undertaken at another institution.

Entomological Studies.

Research on aphids and grasshoppers has continued. The aphid work, although continuing on previous lines, has been concerned principally with a survey of infestation of potato crops by *Myzus persicae* (and other species) in the Isle of Man, with a view to assessing the suitability of various parts of the island as seed-growing areas. Full co-operation with the Manx government has been maintained throughout the investigations. Progress is also being made with an ecological study of aphids affecting shelter trees, notably beech aphis (*Phyllaphis fagi*) and sycamore aphids (*Drepanosiphum* and *Periphyllus* spp.).

Systematic studies on Acridoidea have been chiefly confined to the genera *Atractomorpha* and *Taphronata*, both of which may be injurious to crops, the former mainly in eastern Asia and north-east Australia and the latter in tropical Africa. The taxonomy of these difficult genera was in a very unsatisfactory state, but something approaching order has now been established.

Soil arthropod investigations in the open-cast ironstone workings near Corby have begun, but difficulty has been experienced in devising a suitable extraction technique for the particularly intractable clay soil encountered.

Research into the population dynamics of the Red Rust Grain beetle (*Cryptolestes ferrugineus*) in co-operation with the D.S.I.R. Pest Infestation Laboratories, Slough, has been commenced.

Microbiological Studies

The work on classification of genera, mentioned in 1955, has been developed further by the initiation of studies on *Corynebacterium pyogenes* (cause of summer mastitis), *Microbacterium* spp. (the thermoduric spoilage organisms of pasteurised milk), Arthrobacter (old name of *C. simplex*) spp. (associated with the deposition of iron in soil) and *Rhixobium* spp. (the symbiotic N-fixing organisms).

Work on microbial fats, using both yeasts and moulds, has been continued, again with some financial help from the Medical Research Council. The studies on whey have been extended further by variations in the mineral nutrition of the organisms, to the relation between the fat and protein content of the organisms.

Studies in Dairying.

Preliminary work has been done on the variation of the composition of milk from identical twin dairy cattle, from which it seems that replicated sampling over several consecutive days appears to be necessary. Variations in the protein content of milk from different pasture swards are being followed.

Experiments have been commenced on the process of moisture loss from a curd particle, in order to obtain a better control of synaeresis of the curd in cheese-making.

Further investigations are also being made into the nature of the casein-calcium phosphate complex. Arising out of these, a new method has been developed for the estimation of phosphate.

Farm Management Studies.

During the past year, the routine investigation into farm costs, farm incomes, and enterprise costs has been continued. Studies of production functions for farms have been carried almost to the stage of publication. Analyses of national milk costs for five years, and the relative economies of indoor storage and outdoor clamping of potatoes have been completed and reports are in process of publication.

Work on the economics of combine-harvesting grain is continuing, as is the investigation into the economic features of farm buildings. Special attention has been paid to the housing of dairy cattle and this work will be greatly extended during the coming year. A new study on the prepackaging of vegetables has been commenced, with particular reference to the factors affecting costs and efficiency in pack-house operations for potatoes and carrots.

THE FOURTH EASTER SCHOOL IN AGRICULTURAL SCIENCE APRIL 15th—17th, 1957.

The Fourth Easter School in Agricultural Science was devoted to various aspects of the control of environment in crop experimentation. The use of controlled environments offers attractive possibilities in several fields of research, ranging from fundamental aspects of plant physiology and genetics to applications of immediate importance in plant breeding and agronomy. The wide interest in the field was shown by the attendance of two hundred scientists at the Easter school, including physicists, chemists, biologists, agronomists, horticulturists and engineers, all with a common interest in environmental control but looking at its problems from different points of view. A vigorous exchange of views between such various disciplines proved to be both stimulating and profitable.

Three main themes dominated the proceedings, namely, the relation between the plant and its environment, methods of controlling environment in experimental work, and the possible applications of environmental control in crop husbandry.

Prof. S. J. Wellensiek (Agricultural University, Wageningen) opened the school by discussing the plant and its environment in general terms, distinguishing between variations caused by genetical factors, soil conditions and the aerial environment. After discussing the effects of the main individual factors, with special reference to shifts in temperature optima according to the phase of growth, attention was directed to important interactions between several of the factors, notably photosynthetic light and temperature, photoperiod and temperature, and soil-moisture and relative humidity of the air. Experiments on peanut plants under controlled conditions have revealed relations between weather factors which were hitherto unsuspected, including interactions between soil-moisture conditions and humidity of the air, a high relative humidity giving best growth, especially during the first month.

Attention then turned to detailed methods of using controlled environments in the study of plant behaviour. Dr. W. W. Schwabe (Research Institute of Plant Physiology, London) discussed the differential effects of some environmental factors on plant development, instancing rates of differentiation of primordia and of leaf expansion as examples of the morphogenetic changes which are affected by factors such as temperature, day-length and intensity of illumination. Prof. E. C. Wassink (Agricultural University, Wageningen) placed

the emphasis on plant growth, giving examples of the effects of various environmental factors on such diverse aspects of growth as the production of flowers in bulbous irises and the hearting of lettuce plants. A two-stage growth cabinet has been used for subjecting roots and shoots of a plant to different temperatures in order to study this interaction, which has wide implications in agronomy, since disharmony between soil and air temperatures is frequently cited as the cause of depressed growth in crop plants. Prof. P. T. Thomas (University College, Aberystwyth) showed how controlled environments could be used in plant genetics for the study of the complicated interactions between genotype and environment. A stage appears to have been reached where closer collaboration between the geneticist and the physiologist might be to their mutual benefit.

Light, wind and water were next singled out for separate consideration as important factors of both experimental and natural environments. Prof. R. H. Stoughton and Dr. Daphne Vince (University of Reading) discussed the physical attributes of light in relation to biological responses, taking the growth of a plant as an integrated function of the photosynthetic and formative effects of the various spectral components of light. These effects are being studied under lights of different spectral composition, and data were given on leaf expansion, internode extension and net assimilation under various light sources. Wind as a factor in plant growth was the subject of a paper by Dr. F. H. Whitehead (University of Oxford), who gave an account of an investigation on the effects of wind on the growth of alpine plants under various exposure conditions on a mountain top in Italy, and then described experiments under controlled airspeeds in a wind tunnel. Conclusions were drawn regarding the relation between results in the field and in the laboratory. The complexities of the plant/soil/water system were described by Dr. J. P. Hudson (University of Nottingham), who showed the limitations of using constantly moist soil conditions in experimental work, and the advantages of providing plants with carefully controlled, but fluctuating, moisture conditions. This requires a rigorous control of experimental conditions, but leads to the concept of definable and reproducible water-regimes, which appears to offer a sensitive technique for the study of plant responses to soil water. It became clear in all these papers that the meteorologist, ecologist, physiologist and agronomist could also, with advantage, meet more often to exchange ideas based on their different approaches to the same phenomena.

Technical aspects of environmental control were the theme of two speakers. Mr. W. J. C. Lawrence (John Innes Horticultural

Institution, Bayfordbury), discussing the glasshouse as an environment for plant experiments, appraised the possibilities of achieving a high degree of control of various factors, especially temperature, light and relative humidity. Several interesting suggestions were made for improving the efficiency of glasshouses used for experimental work, including the possibility of end-to-end ventilation instead of the traditional lateral method. The central problem is how to reduce gradients of environmental factors in both space and time. Mr. L. G. Morris (National Institute of Agricultural Engineering, Wrest Park) described problems involved in the design of growth rooms and cabinets used for plant experiments and appealed for more information on the tolerance which could be accepted in time and space. Many installations, designed without adequate data on their use or characteristics, are either much too elaborate for the uses to which they are put, or else will not provide the degree of control that is needed. Both faults, basic in the design of the equipment, lead to waste and frustration.

In the final session concerning agronomical aspects of environmental control, Prof. A. H. Bunting (University of Reading) gave a stimulating paper that concluded the proceedings on a high note of interest in the possibilities of increasing crop yields, even in the open, by slight but carefully controlled changes in various factors of the physical environment. The best prospects of striking improvements in crop yields appear to be the more efficient use of irrigation water, the application of nutrients by leaf sprays at critical stages in plant development, and the use of low-intensity irradiation to break the period of darkness and induce earlier flowering in some species. This should be coupled with intensive breeding programmes to develop varieties that can take maximum advantage of more carefully controlled environments.

In addition to the main sessions, two evening meetings were devoted to technical descriptions of installations now being used for the control of environment. In a prolonged discussion on policy and planning, the national advantages of having a small number of large, comprehensive and necessarily expensive 'phytotrons' were compared with having a much larger number of simpler and cheaper installations. The general opinion seemed to be that, at the present stage of knowledge, the advantage lay in the latter approach, which was likely to produce more results, more quickly, for a given total expenditure on capital and running costs. Descriptions were given of several patterns of growth rooms and of relatively small and inexpensive growth cabinets that are giving a high degree of control

of light, temperature and humidity. There were also about thirty demonstrations of the effects of environment on plant growth, equipment for the control of environment and instruments for measuring environmental factors.

Although this hard-working school only lasted for forty-eight hours, the growing interest in environmental control was amply demonstrated. It was generally felt that the potentialities of this relatively new technique, which offers a wealth of possibilities in the study of plants and cultivation of crops, have only just commenced to be appreciated.

A summary of the proceedings on the above lines was published in Nature, **179,** 1173-5, 1957, and the full proceedings were published by Butterworths Scientific Publications, London, in December, 1957 under the title "Control of the Plant Environment", price 42s. 0d. per copy.

IRON PAN FORMATION IN THE SOILS OF THE UNIVERSITY FARMS

E. G. Hallsworth and N. Ahmad.

The soils of the University farms have been developed largely on the fluvo-glacial sands and gravels laid down over much of lowland England during the inter-glacial phases and at the close of the glacial period. They occur here as a thin drift, varying in thickness, from a few inches to several feet, overlying the Keuper marl.

The fluvo-glacial material itself is largely derived from local rocks. It includes sand and pebbles from the Bunter sandstone, clay from the Keuper, limestone fragments from the various limestone and calcareous shales and is generally neutral to slightly alkaline in the lower and less weathered horizons. The mixing of these various components has not been very thorough, and quite gross irregularities can be observed on close inspection. The most notable of these are where relatively large blocks of Keuper marl have been deposited with little disruption. A pit through the edge of such a block might easily show a sandy loam profile through one half and a medium clay in the other. This could be seen in the excavations for the new building (Plate 1).

In other parts a continuous but quite thin layer of clay, interbedded between sands and gravels may occur, presumably when one or several small blocks of clay disintegrated and spread out to form a layer that was subsequently covered by material deposited later. These clay layers are quite random in their occurrence, but where they occur drainage is considerably impeded, the soil developing shows the characteristic symptoms of mottling, and ironstone concretions may occur.

The type of concretion found varies in different situations, the most noteworthy being the massive form, where a coarse gravel layer up to twelve or fourteen inches thick has been cemented into a solid block by the deposition of ironstone in its interstices (Plate 2). Lateral continuity of the deposit depends on the continuity of the gravel layer, and since this is variable, the concretions occur in irregular patches over a large area.

Where large stones are absent, a smaller form of concretion occurs, about three to five inches in diameter, which is intermediate between the massive and the nodular forms of ironstone. What may be described as nodular concretions occur under generally similar environments to the previous two forms, but where gravel is absent and the layer immediately above the clay band is of sand. Mineralogical examination* of the concretionary material shows that only a small part of the iron oxide in the concretions is crystalline, the minerals present being haematite and goethite.

A topographic and soil survey of most of the Experimental Farm has now been completed, and over certain parts test wells have been put down on a close grid. From these it has been possible to show that where a clay layer occurs in the profile 4—5 feet deep, and the overlying soil contains a stony layer, water accumulates above the clay band. Measurements have shown that where such a profile occurs on relatively flat land, or in depressions, the ground water will rise during the winter to a depth of one foot or less from the surface, whilst in summer the water table recedes to six feet or deeper. In many cases it seems that the clay band occurs as a saucer or shallow basin-like depression, even although the land surface itself may appear quite flat, for the test wells have shown that the water table in such a case may lie at 12 to 18 inches from the surface, no more than six feet away from an open ditch, five feet deep, in which barely a trickle of water was moving. The alternation of waterlogging and aeration

*The X-ray photographs were taken in the Departments of Physics and Metallurgy, whose co-operation is greatly appreciated.

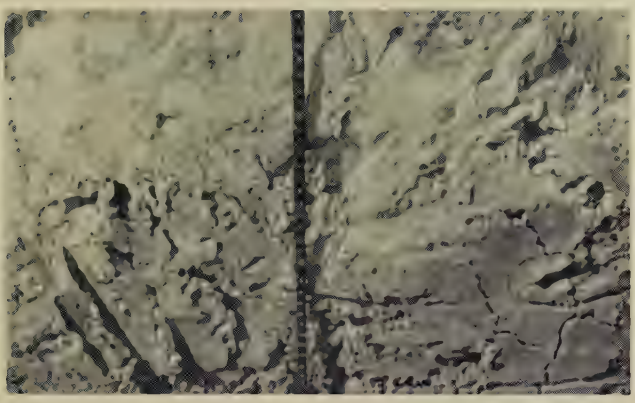

Plate 1a. At this point of the excavation about 3ft of gravelly sand overlay the block of Keuper Marl, and was sharply demarcated from it.

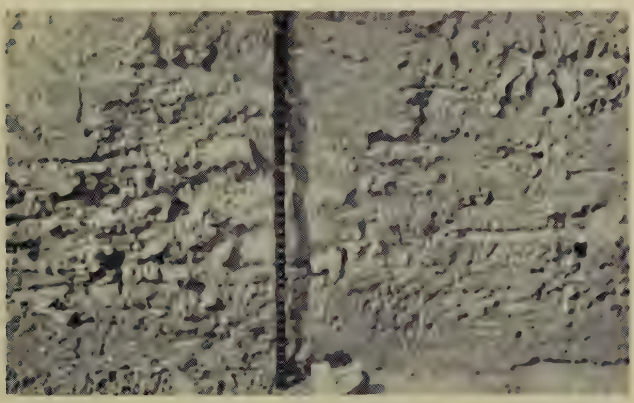

Plate 1b. At the bottom right hand corner sandy material can be seen oozing out from beneath the block of Keuper Marl.

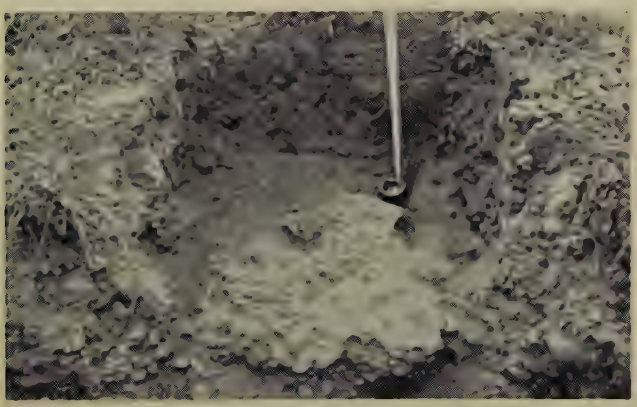

Plate 2. Massive concretion, formed where a coarse gravel layer has been cemented into a solid block by deposition of iron oxide in its interstices.

caused by the rise and fall of the water-table dissolves the oxides of iron and manganese in the soil, and allows their redeposition in the overlying stony layer, resulting in its gradual cementation into massive ironstone. In similar situations, but where the stony layer is replaced by sand, the deposition occurs as separate nodules of varying size. Other smaller concretions are found in the mottled part of the soils and in the disturbed clay bands. These are either red or very dark brown in colour, the former are almost pure haematite, whilst the latter are distinctly richer in manganese. The presence of iron and manganese in measurable amounts in the ground water, suggests that the deposition of ironstone is still taking place at the present day.

The drainage of such areas is likely to present considerable difficulties unless preceded by an adequate survey.

THE EFFECT OF ALUMINIUM ON THE GROWTH OF CERTAIN LEGUMINOUS SPECIES.

I. H. Rorison.

The effects of soil acidity on plant growth are complex. Acidity itself may limit root growth or in the case of legumes, may restrict the growth of associated bacteria. In acid soils, calcium is often in poor supply, whilst the availability of other nutrient elements such as molybdenum may be seriously lowered. Work at other centres, and notably by Wallace[1], Hewitt[2] and their colleagues at Long Ashton, has shown, however, that as soil acidity increases, so the levels of manganese and aluminium present in the ionic form also increase. When certain plant species are grown in such soils, a severe check on growth occurs, whilst in extreme cases there might be absolute toxicity. It is doubly interesting to find that other species, sometimes closely allied, are largely immune from these setbacks. At the School of Agriculture, attention has recently been focussed on the effects of aluminium on the growth of some leguminous species.

Acid soils in which there is likely to be sufficient aluminium to cause this toxicity are widespread and have been extensively investigated. The immediate remedy is to lime the soil whereby the pH is raised and the aluminium ion is precipitated mainly in the form of hydroxide. Such a treatment, however, may pose certain difficulties in the field, and the problem today is to discover the mechanism of the toxicity. Attempts to do so have been hampered because aluminium has no known metabolic role in plant nutrition.

Much early work on the soil acidity complex tended to minimise the effect of aluminium in favour of other factors. This was due mainly to four features of the experimental techniques adopted. In the first place the investigators did not maintain adequate control of the growth media. Secondly, there was a lack of analysis to show how much of the elements added were actually in solution. Thirdly, seedlings were frequently raised in compost or complete nutrient solutions for several weeks before being transferred to the aluminium containing medium. Lastly, the species used were not always selected for the degree to which their natural distribution was dependent upon the chemical nature of the soil. More recent work has done much to clarify the situation[3].

Work at the School of Agriculture has made use of the acid soil species ; lupin (Lupinus luteus) and seradella (Ornithopus sativus),

the widely tolerant white clover (Trifolium repens) and the alkaline soil species, sainfoin (Onobrychis sativa) and lucerne (Medicago sativa). Over a pH range from 4.0—7.5, and aluminium concentrations from 0—50 mg per litre*, factorial sand and water culture experiments showed no significant difference in yield due to aluminium for lupin and seradella. The depressive effect on white clover was slight, while both acidity and high aluminium concentration had a marked effect on sainfoin and particularly on lucerne.

Subsequent detailed experiments using water cultures in which the nutrient level, pH and aeration were strictly controlled, confirmed these results for lucerne, sainfoin and seradella. As had already been shown with some other species[4], aluminium toxicity was most intense during the very early seedling phase. Growth of seedlings germinated in acid solutions of high aluminium concentrations, was compared with that of more mature plants raised in normal nutrients or compost before transfer to the acid solutions. The effect of the high aluminium concentration on the latter group was much less and in some cases no toxicity symptons appeared. It was interesting to note that lucerne with very small seed reserves was much more drastically affected than sainfoin which has a much larger seed. The most marked symptoms of aluminium toxicity were the stunted roots whose peg-like stumps were lateral root initials which had failed to penetrate the cortex. The cotyledons and older leaves showed a deep reddening similar to that associated with phosphorous deficiency.

Chemical analyses of root and shoot fractions confirmed a significantly high concentration of aluminium in the roots of the stunted plants and a significantly low concentration of phosphorous in their shoots. Analysis for other inorganic elements showed a response to changes in the nutrient medium, but the most marked effect was the general lowering of the concentration in the plant tissue of all other ions when the aluminium concentration of the nutrient solution was increased in solutions between pH 4—5.

The next step taken was to test the effect on aluminium toxicity of varying growth rates. These rates were induced by growing the plants under varying climatic conditions in the plant growth rooms. The hypothesis was that, whereas manganese with its known metabolic role in the plant caused a toxicity which was cumulative, and whose rate increased with increasingly favourable conditions for growth[5], aluminium toxicity was non-metabolic and did not depend on active uptake of the ion. If, therefore, the seedling could grow rapidly through the crucial seedling phase, the toxic effect of aluminium would decrease rather than increase.

Within certain limits this proved to be so. At 40 mg per litre* aluminium the toxicity was lethal at all six growth rates used, and the crucial phase was not passed. At 20 mg per litre and less, the toxicity was overcome at rates which varied with the climatic conditions and the solution's aluminium concentration.

Work over a number of years (Wright, K.E. 1937-1953)[6] has shown that in affected plants aluminium and phosphate accumulate in the cortical region of the roots. Evidence to date suggests a cell surface reaction rather than one following on active salt uptake. Advances in cell physiology may make it possible to identify more specific sites of activity, and also to elucidate the physiological differences by which lupin and seradella survive, while sainfoin and lucerne succumb to toxicity. Work towards this end is continuing.

*The aluminium concentrations mentioned denote the theoretical maximum. The actual concentrations in solution depend mainly upon pH, and upon the concentrations of phosphate added. Similarly, although theoretically the phosphate concentration was constant, the amount in solution decreased with an increase in aluminium. An investigation into this variation is yielding further information on the relative roles of aluminium and phosphate.

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EFFECTS OF SOIL SALINITY ON GLASSHOUSE CROPS.

D. W. T. Clay and J. G. Davison.

Introduction.

The availability of soil water to plants is determined largely by the **soil moisture tension** and the **osmotic pressure** of the soil solution. These two forces, added together, constitute the total **soil moisture stress**[1].

Experiments previously reported [2, 3, 4, and 5] have been concerned with the influence of soil moisture tension on growth of tomato and lettuce plants under glass, but soil water always contains some dissolved salts, which affect its osmotic pressure and hence its availability ; the effects of soil salinity are now being studied as a logical development of the earlier work. Instead of subjecting plants to different moisture tensions, whilst keeping osmotic pressure of the soil solution low, the degree of soil salinity has been varied, in beds of soil which were maintained at constantly low moisture tensions. In this way it has been possible to determine the salinity level at which growth and yield begin to be adversely affected. Moisture tension was maintained near the optimum for growth by watering whenever tension reached the low figure of 7 cm of mercury at any depth, i.e. only 3 cm above the tension at field capacity in this soil.

Before the commencement of the experiments, all plots were leached to uniformly low levels of salinity. One set of plots was then kept at low salinity whilst other plots were salinised to different levels by the addition of various amounts of a 3:1 mixture of potassium sulphate and hydrated magnesium sulphate respectively, at rates equivalent to 9, 18 and 27 tons per acre. This mixture, chosen because the salts provide some of the major ions which normally accumulate in glasshouse soils, was applied in solution in an attempt to ensure distribution evenly throughout the soil profile, although in practice the method always resulted in a higher concentration of salts in the upper layers of soil than at lower depths.

Tomatoes.

In one experiment, two varieties of tomato, Ailsa Craig and Potentate, were subjected to each of the four treatments. Differences between treatments were visible soon after planting, when plants in the non-saline plots made rapid, relatively soft growth with pale green foliage, whereas those in the most saline beds grew more slowly, were dark green in colour, and after a period of two to three weeks

showed characteristic bunching of the young leaves. Plants in the other two treatments were intermediate in character. After mid-June, differences between treatments became progressively less marked, both in foliage colour and in the type of growth, until it became difficult to distinguish between the growth made by plants in any of the four treatments by the end of the season (September).

Changes in the degree of salinity in the soil, regularly assessed by soil sampling at two levels, showed that salts were gradually leached by irrigation water to the lower horizons in the saline treatments, so that salinity fell in the surface layers of soil but increased in the lower layers as the season progressed. This was probably the main reason why differences between treatments became less apparent, since active root systems in the surface layers of soil in the salinised plots experienced decreasing salinity levels as the season advanced.

Yields of fruit showed similar trends to vegetative growth. During the last seven weeks of the season there were no significant differences in the amount of fruit picked from the four treatments, although there were marked treatment differences during the first two months of cropping, during which time the weight of fruit picked from Ailsa Craig ranged from 6.1 lbs. per plant in the non-saline plots to 3.8 lbs. in the most saline plots. The average number of fruits picked per plant during this first phase also varied, from 46 in the non-saline to 36 in the most saline plots. A general decrease in the mean weight of fruit, with increase in salinity, was shown by the results of grading for size, a much greater percentage of larger fruit occurring in the non-saline, compared with the most saline, treatment.

Fruit from the saline plots matured rather more quickly, but in the earlier part of the season many of the fruits showed symptoms of blossom-end rot, whereas this disorder did not occur at all in the non-saline plots. Blossom-end rot has often been attributed to lack of water but in this case, of course, the soil was constantly wet, and any effects of shortage of water in the plant must have been due to high osmotic pressures in the soil solution rather than to an absolute lack of water. It was observed that blotchy ripening, an important physiological disorder of tomato fruits, occurred only in the non-saline plots, where it was three times more prevalent in the variety Potentate than in Ailsa Craig.

From this it appeared that soil salinity can become a limiting factor to maximum crop production, even in soils kept constantly moist, at a value that can be deduced in the following way. The rate of growth was very similar in all treatments from mid-June on-

wards, by which time the salinity level in the most saline treatments had fallen to a pC value of 2.9* in the active rooting zone. This pC figure can therefore be regarded as the level (i.e. lowest salt concentration) at which crop production is likely to be reduced if the soil is kept wet. If, however, soil is allowed to dry out between irrigations, then a lower concentration of salts is likely to be critical, since moisture tensions and total soil moisture stress will both be higher.

In a similar experiment with the varieties Ailsa Craig and Moneymaker, the same four main treatments were used, but half the replicate plots of each treatment were dressed with gypsum (calcium sulphate), worked into the top 12 inches at the rate of 10 tons per acre. This amount of gypsum, commonly found in old glasshouse soils, was ample to saturate the soil solution under any moisture conditions because of the sparing solubility of calcium sulphate in water, and there was no point in using larger amounts. The presence of accumulations of gypsum has frequently been alleged to cause a reduction in the yield of tomatoes but differences in yield between plants grown at any particular salinity level, with or without gypsum, were small and not significant in this experiment. It would seem important, therefore, when considering the minimum level of salinity which will affect crop yield, to pay due regard to the actual ions which comprise the salts, as well as to the total concentration of salts in a soil—information which does not, of course, become apparent from assessments of pC values based on the total effects of all the salts in the soil solution on conductivity.

Lettuce.

Cheshunt 5b lettuces were grown under similar soil conditions to those described above. With lettuce, where the growing period is much shorter and the amount of water applied is only a fraction of that required by tomatoes, the very slight drift of salt occurring down the profile did not appear to affect the results of different treatments.

The effects of high soil salinity were apparent within a few days after planting out. During the first fortnight plants in the salinised plots wilted when the temperature approached 80°F, whereas those of the unsalinised plots remained turgid at all times, even at temperatures in excess of 80°F. Increased salinity produced more intensely coloured plants, which were smaller than the controls. All treat-

*Soil salinity is assessed by measuring the electrical conductivity of a soil suspension. The value obtained (in mhos) is converted to its negative logarithm, which expresses the pC value, a figure which can range from as high as 4.0 in soils containing virtually no soluble salts to 2.0 in soils carrying a very heavy burden of salts indeed. The normal range for glasshouse soils is from about 3.8—2.6.

ments were harvested when the control plants were commercially mature. Mean fresh weights of the controls were found to be more than twice those of plants subjected to the highest salinity treatment, and significantly greater than those at the lowest level of induced salinity (pC value of 3). Increasing salinity appeared to increase the percentage of dry matter per plant, but not the total yield of dry matter. Apart from being smaller, plants growing in salinised soils were also slower to heart and more prone to Botrytis and tip-burn, two diseases which are of economic importance in the commercial production of glasshouse lettuce.

Conclusions.

These results are of practical importance. Soils in many commercial glasshouses in Britain contain large amounts of soluble salts, which are mainly the result of the application of fertilisers such as superphosphate and sulphate of potash at total rates often approaching two tons per acre per annum. As a result, fertiliser residues gradually accumulate over the years, unless large volumes of water are applied between crops to leach the soluble salts out of the soil.

The general conclusion can be drawn that more attention should be paid to preventing soluble salts from accumulating in glasshouse soils. This can be achieved by using the minumum of fertilizers required for optimal growth, and by the use of sufficient water between crops to wash out surplus salts, but where plants have to be set out in soil containing an undesirable concentration of salts, salinity effects can be minimised by keeping the soil as moist as practicable, thus preventing high moisture tensions from increasing the total soil moisture stress beyond the level caused by the osmotic pressure of the soil solution.

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CHOKE OF GRASSES.

E. J. M. Kirby.

Choke is a common disease of both cultivated and weed species of grasses. Infected plants can be found in permanent grassland shut up for hay and among flowering grasses on roadside verges. It is only economically important where grass is being grown for seed. In this country the disease has caused concern to growers of cocksfoot seed, as over 20% of plants in a three-year old stand may be infected. The disease occurs mostly on perennial grasses, but there has been one report of the disease occurring on wheat and rye. Rye grass does not appear to be affected by the disease.

The disease is so called because the inflorescence is choked off by the causal fungus (Fig. 1). The fungus (*Epichloe typhina*) forms a dense weft of hyphae which binds the young inflorescence tightly in the leaf sheath. This weft of hyphae, or stroma, first produces conidia and later ascospores.

Studies of the fungus have shown that it is systemic in the host plant, the fine hyphae being sparsely distributed in the leaf, stem, rhizome and other vegetative organs. The mucelium is perennial and an infected plant can produce choked flowering stalks year after year. It is however only when the plant flowers that the fungus manifests itself; during most of the year it can only be detected using microscopical techniques. Some grasses infected with the fungus, notably red fescue, flower more or less normally and produce considerable amounts of seed. This seed contains fungal hyphae and plants grown from it are nearly always infected.

Except for spread of the disease by seed the method of infection of a grass by the fungus is uncertain. The fungus produces abundant spores but it has never been satisfactorily demonstrated that these can infect healthy plants. The fungus can grow on dead leaves which have been surface sterilized and inoculated with a spore suspension; whether or not this is of any significance in natural infection has yet to be explored.

One interesting feature of the disease is the association of stroma production with the flowering of the grass plant. To study this phenomenon in more detail the development of the inflorescences of some grasses was followed. From early in April when the plants were still vegetative until June when flowering was evident the shoot apex of infected plants was dissected and examined. This shoot

apex in the early stages of growth produces leaves and later forms the inflorescence. When vegetative the shoot apex of an infected plant was quite normal, being indistinguishable from an apex of a healthy grass (Fig. 2). A little later in the season the inflorescence was initiated, as detected by the appearance of the apex (Fig. 3). At this stage—"the double ridge" stage—the apex was still more or less normal. Soon after the double ridge stage, the effect of the fungus became apparent. Instead of each ridge developing normally to form a branch of the panicle, with spikelets and florets, it becomes malformed (Fig. 4). This malformation is due to the differentiation of the flowers being arrested. A short time later hyphae of the fungus grow out from the young inflorescence. The mycelium fills the space between the inflorescence and the young leaf enfolding it. All the intercellular spaces in this and surrounding leaves become filled with the mycelium which binds these leaves firmly together. Elongation of the lower internodes proceeds as in an uninfected grass carrying the inflorescence, bound into the fungal stroma, clear of the older leaf sheaths. The internodes between the leaves, which are trapped, usually do not elongate.

This process is similar in all species examined, only minor differences being observed in the stage to which the panicle developed before its growth was halted. In *Agrostis stolonifera* some plants produced panicles only parts of which were invested in a stroma. Here some parts of the panicle were prevented from developing while other parts produced more or less healthy spikelets.

This behaviour shows that stroma production is directly stimulated by some change in the plant which occurs when the inflorescence is first formed. In order to explore this effect further, infected grasses were treated so that they would flower (or produce stroma) out of season. As most grasses from temperate regions flower only when the duration of daylight is greater than about 12 hours, one set of plants was exposed to a day length of 18 hours (the day being extended by artificial light), a second group were allowed 10 hours light per day only, while a third were grown under the normal increasing day lengths of spring (14-17 hours). All other conditions were similar. Plants of cocksfoot (*Dactylis glomerata*), timothy (*Phleum pratense*) and Yorkshire fog (*Holcus mollis*) grown in long days flowered about 4—6 weeks earlier (21st—28th April) than plants in natural day length. Intense activity of the fungus and stromal formation followed differentiation of the flowers in both groups. The short day plants produced neither flowers nor stromata until June, when they were transferred to natural day lengths. Flowers were differentiated about two weeks later and the fungus then formed stromata.

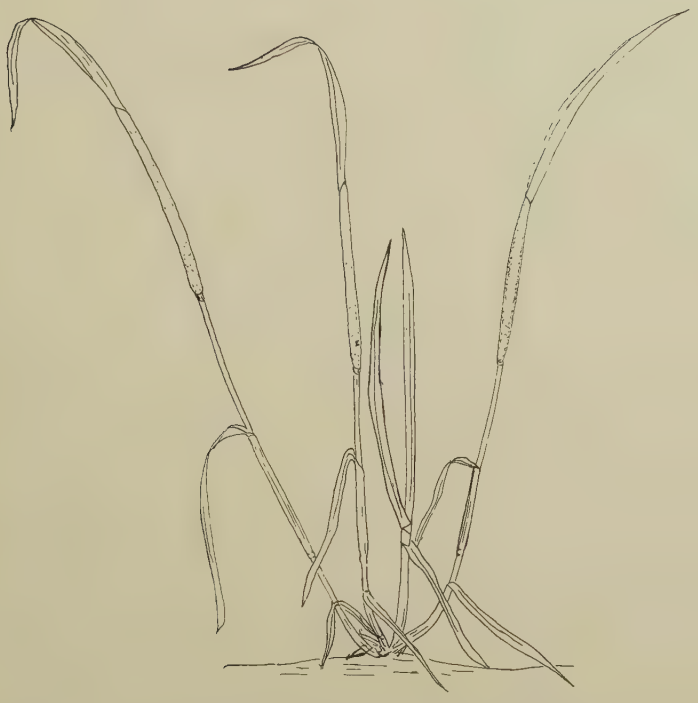

Figure 1. Infected cocksfoot plant showing stroma. Initially this is white; later it becomes orange and produces ascospores.

Figure 2. Vegetative apex of infected cocksfoot.

Figure 3. Double ridge stage of an infected cocksfoot tiller.

Figure 4. Apex of an infected cocksfoot tiller showing malformation due to the disease.

Creeping bent grass (*Agrostis stolonifera*) behaved quite differently. In long days, differentiation of the inflorescence was rapid and normal panicles were produced. The florets, however, contained hyphae of the fungus and the seed which was produced was not viable. In natural daylengths, some plants produced normal panicles but others were completely choked. In short days, followed by transfer to long days in June, flowers were not produced and choke did not develop.

These observations suggest that change in the fungus from the state of slow intercellular growth and benign tolerance by the host grass to that of rapid growth and rampant parasitism is associated with some change in the growing apex of the stem occurring on differentiation of the infloresence. This conclusion was supported by further experiments under controlled conditions of light and temperature. It seems that there is a fairly brief and limited stage of development of the inflorescence which encourages the active growth of the fungus. Until the inflorescence reaches a length of 2—4 mm., the fungus can grow only slowly. After the inflorescence has grown to 8—12 mm. and the florets are differentiated, fungal development is again slow. Success of the fungus to grow rapidly and to produce stromata and spores depends on its ability to take advantage of this limited period. If the growth of the inflorescence over this period is slow, then the fungus can develop. If growth is rapid, however, then the inflorescence may pass through this critical period before the fungus can develop extensively and choke does not occur. The exact morphological, nutritive or physiological conditions, which occur in the apex during this short period of development and encourage such rapid growth of the fungus, still remain unknown.

COMPETITION BETWEEN WHITE PERSICARIA AND BARLEY

D. Aspinall.

A plant species must possess several characteristics before it can become a successful weed. For example, it must be able to reproduce itself readily, either by seed or vegetative organs, and it must be able to grow at the same time as the cultivated crop in which it is a weed. A crop is usually sown at a time when its seeds germinate readily and all other growing plants are destroyed by the attendant cultivations. The extent to which any weed species will influence the growth of the crop depends on the ability of the weed to germinate at or about the same time as the crop plant and to grow at an equal or faster rate than the crop i.e. to compete with the crop for available nutrients and for light. These principles are illustrated by the differing growth behaviour of barley and of white persicaria (*Polygonum lapathifolium*), a frequent weed of cereal crops.

Barley and white persicaria were germinated at the same time and grown, both in pure stand and mixed, at different densities. In pure stands, it was found that the white persicaria grows more rapidly than barley. However, the embryo of white persicaria is very much smaller than that of barley and this initial disadvantage in the amount of growing material is such that white persicaria never reaches the same size as barley until late in the season. When grown together, the barley has the great advantages of larger initial size and more extensive branching at an early stage of growth and is thus able to suppress the growth of white persicaria, which grows much more slowly when mixed with barley than with an equal density of its own kind. Consequently, throughout the early stages of growth (until after flowers of barley emerge), white persicaria has little effect on the growth of barley. With the formation of flowers and development of the grain of barley the older leaves senesce rapidly and the smaller persicaria plants then begin to grow faster. White persicaria also has the ability to form branches from the upper buds on its stems and these develop extensively. The plants of white persicaria are growing vigorously at the time when the grain is being formed by the barley. Photosynthesis in the inflorescence and in the flag leaf of barley makes a considerable contribution to the total yield of grain ; shading of these organs by the now taller persicaria may reduce the yield appreciably. However, flowering and seed formation of white persicaria are rapid and many ripe seeds are present at the time of harvest. Seeds of white persicaria and other species of polygonum occur frequently in samples of cereals grown in this country.

The differences in growth with time of the two species arise from their relative ability to use the light falling on the crop and the nutrients in the soil. Competition for these factors of growth also occurs between individuals of the one species. Thus as the density of planting is increased, plants become crowded at an earlier stage of growth. The leaves of each plant shade the leaves of adjacent plants and the root zones of the plants overlap, thereby reducing the absorption of nutrients by the root. Each individual plant therefore grows more slowly than when it is widely spaced. The prime factor which is responsible for this reduction in growth is still uncertain. Certainly with mutual shading of the leaves, the mean intensity of light falling on the total leaf surface of each plant is reduced. This causes a reduction in the rate of assimilation of carbon dioxide per unit area of leaf and contributes to a reduction in the size of the leaf surface. It is also possible that there is a direct effect of light on leaf growth. The rate of expansion of the roots of individual plants is also decreased but, due to the increase in plant density, there is a greater concentration of roots in unit volume of soil and consequently the concentration of nutrients around the roots falls. The growth rate is also decreased due to a reduction in the uptake of mineral nutrients by each plant because of the decreasing concentration and the smaller surface area of the roots.

When barley is grown in pure stand, there is a marked reduction, with increasing density at any one time during growth, of the weight of each plant. This arises mainly from a reduction in the number of tillers (branches from ground level) which are formed, and also from the growth of each tiller. This reduction is mainly due to a decrease in the net assimilation rate and apparently also to a direct effect of light on tiller development as well as to a reduction in uptake of nitrogen and phosphorus due to a smaller root surface. Similar effects are found with white persicaria in pure stand where there is again a reduced rate of assimilation and complete suppression of all axilliary branches at the higher densities.

When the two species are mixed together the larger size of the embryos of barley allow this plant to reach a larger size, as shown by greater dry weight, greater height and deeper penetration of roots. This initial advantage of the barley allows it to continue at a normal rate of growth ; in fact, the growth of a barley plant surrounded by a number of persicaria plants is faster than when surrounded by an equal number of barley plants. White persicaria then has little effect on the growth of barley, until late in the season when the death of leaves and cessation of root growth of the barley allow sufficient

penetration of light and nutrient uptake for the persicaria to branch and grow vigorously. On the other hand, white persicaria is greatly suppressed by barley until late in the season ; a persicaria plant surrounded by barley is suppressed much more than when surrounded by an equal number of persicaria plants.

It has been found in this and other studies that there is rarely any differential mortality of seedlings in populations of plants, of like or of different species, germinating at the same time, even in comparatively dense stands. Rather, there is a considerable reduction in the size of each plant comprising the population and if one species has an advantage, as barley in this instance, then the other species is greatly reduced. The greater the density the greater is the reduction in growth rate. This means that at any time during growth there is an increase in the total yield of dry matter per acre up to a certain density ; any increase in density beyond that point leads to no further increase (or decrease) in yield. The level beyond which any increase in density has no further effect on the yield per acre changes during the season, as it is a direct consequence of the amount of growth made. Therefore as the season progresses this point is reached at a continually decreasing level of density.

CROP VARIETY TESTING

T. Webster.

The main series of trials of the National Institute of Agricultural Botany was continued in 1957 with a few alterations. The early potato trial was terminated but several foreign varieties, resistant to common scab and to some extent to blight, were tested in trial and observation plots. The winter bean trial was replaced by one having a single strain each of a winter and a spring bean, with various manurial and spraying treatments. A time of sowing sugar beet trial was reintroduced, in addition to the main and small scale trials. For the first time a kale trial was laid down, comprising four strains of Thousand Head kale ; two French and two English.

Wet seed bed conditions, and the dry early summer caused the spring cereal trials to be rather poor. Drought also affected the spring beans, but autumn sown cereals and beans gave good crops. Other trials were satisfactory, despite a fairly heavy attack of potato blight and virus yellows of beet. The following are the main 1957 results, which by themselves have a limited application, and should be used only as a very tentative guide to varietal performance.

Cereals and Beans.

The control variety is listed first, and the yield given in cwts. per acre. The yields of other varieties are expressed as a percentage of control, and are in heavy type where they differ significantly (5% level) from control. All yields are at 15% moisture content, and are the means of yields obtained at three levels of nitrogen.

WINTER WHEAT TRIAL.

c/a=cwts. per acre

Hybrid 46	Bersee	Leda	Mado	Marne Desprez	Merlin	Panter	Tavero	Vilmorin 53	Flamingo	Marsters 57	14410	9/3/1	Cappelle Desprez
c/a													
40.6	100	96	96	**95**	98	97	98	99	102	100	**92**	**94**	104

Merlin, 14410 and 9/3/1 were rather susceptible to yellow rust. Lodging was not serious, but rather worse in Bersee and Merlin.

SPRING WHEAT TRIAL.

Atle	Koga II	Ritchie	Teutonen	Alfy II	Jufy I	Phoebus
c/a						
23.0	**116**	96	**107**	**60***	**118**	**112**

*Suffered severe shedding during high winds on 25th August.

Jufy I was rather susceptible to yellow rust.

SPRING BARLEY TRIAL.

Proctor	Glasnevin No. 3	Ingrid	Pirol	SAK 22/11	Frisia	Wisa
c/a						
32.7	96	98	**60***	94	**57***	**85***

*Suffered from bird damage before harvest.

SPRING OATS TRIAL.

Sun II	Blanche de Wattines	Civena	Deva	Flamande Desprez	Pendek	Nestor	16004	4757/6/2/19
c/a								
25.0	**76**	102	102	**82**	**81**	98	102	97

In the Spring-Winter Bean Trial, yield differences due to spraying with a systemic insecticide, and to various levels of phosphate and potash manuring, were very slight.

The mean yields of all treatments were

Garton's S.Q.	27.1 c/a
Albyn Tic	16.9 c/a

Potatoes.

Majestic was the control in both trials, and its yield is given in tons per acre, the yield of other varieties being expressed as a percentage of control. Different stocks of Majestic were used in the two trials, and this is the only factor to which can be attributed the difference in yield between the controls in the two trials.

Ulster Torch again showed a considerable degree of foliage resistance to blight and Å°s and Ulster Supreme, although attacked, were very slow to succumb. 480/51 was also highly resistant to blight, but seemed very susceptible to virus, and in the event gave a high proportion of small tubers.

MAINCROP POTATO TRIAL.

t/a=tons per acre

	Majestic	Arran Viking	Ulster Beacon	Ulster Supreme	Ulster Tarn	Ulster Torch	480/51
	t/a						
Total	20.08	96	81	103	91	116	97
Over 1¾"	19.79	98	82	104	92	115	93
Over 2"	14.35	117	89	121	97	84	35

FOREIGN POTATO VARIETY TRIAL.

	Majestic	Å°s	Cayuga	Seneca
	t/a			
Total	14.66	115	100	89
Over 1¾"	14.43	116	100	91
Over 2"	9.94	100	109	117

Sugar Beet.

Sharpe's Klein E was the control in each trial, and the data are related to it as a percentage. In the time of Sowing Trial the normal sown Sharpe's Klein E is taken as standard. The results are provisional, as they exclude weights of samples.

MAIN SUGAR BEET TRIAL.

	Sharpe's Klein E	Eagle Hill Poly	Klein E (East Zone)	Maribo Poly	Zwaanesse III
Population/acre	29,320	80	91	85	96
Bolters/acre	216	368	83	180	4
Yield of Tops t/a	14.12	87	107	96	108
Yield of Washed Roots t/a	15.07	86	95	88	102
Sugar %	15.55	16.00	15.55	16.80	15.85
Yield of Sugar t/a	2.34	88	95	95	104

SMALL SCALE SUGAR BEET TRIAL.

	Sharpe's Klein E	British S. K. W. Line 61	Bush Poly (S)	Bush Poly (X)	Belge X E	Dieckmans E	Rimpau E	Schreibers E
Population/acre	27,150	93	83	86	97	90	83	90
Bolters/acre	115	120	160	80	200	1,063	742	1,223
Yield of Tops t/a	11.51	111	104	102	109	112	102	107
Yield of Washed Roots t/a	15.29	95	95	99	92	90	86	85
Sugar %	16.15	16.00	16.05	15.95	16.25	15.65	16.00	15.80
Yield of Sugar t/a	2.47	94	94	98	93	87	85	83

TIME OF SOWING SUGAR BEET TRIAL.

	NORMAL				EARLY			
	Sharpe's Klein E	Battle's E	Bush E	K.N.B.	Sharpe's Klein E	Battle's E	Bush E	K.N.B.
Population/acre	28,390	101	95	96	97	93	99	97
Bolters/acre	230	30	30	0	730	870	850	100
Yield of Tops t/a	15.33	101	105	95	107	105	109	104
Yield of Washed Roots t/a	14.54	99	95	92	109	103	104	97
Sugar %	15.90	15.70	16.00	16.35	15.75	15.80	15.55	16.25
Yield of Sugar t/a	2.31	98	96	95	108	102	102	99

Sowing dates : 16th April and 28th March.

Kale.

The Thousand Head Kale Trial had several treatments: three levels of nitrogen, singled and unsingled, and three dates of cutting. The English types were—Cannell's "Thousand Head" and "Canson" the French—"Poitou" and "Sarthe".

The mean total yield of fresh material was 24 tons per acre and there were no significant varietal or treatment differences. Singling and early cutting gave a higher proportion of leaf, Poitou being the leafiest kale. Dry matter yields were decreased by singling and in this case by additional nitrogen. Yields of crude protein showed no significant treatment or varietal differences, though the English kales, particularly Canson, were rather better.

Miscellaneous.

In addition to the series of main trials, demonstration and observation plots of winter and spring cereals were laid down, including plots to assist in determining the spread of yellow rust and the effect on yield of mildew in barley.

Fifty strains of mangels and fodder beet, and twenty of thousand head and marrow stem kale were grown in observation plots.

Seven small scale grass trials were continued, mostly sward plots of different strains of Meadow Fescue and Ryegrass, with S100 white clover, including one spaced plant trial of thirteen strains of Meadow Fescue, containing almost a thousand single plants.

THE PRODUCTION OF BARLEY FOR FEEDING.

J. D. Ivins.

The requirements for malting barley are virtually categoric and to some extent these requirements, for example a low nitrogen content, frequently preclude attempts to produce maximum yields per acre. Choice of variety and manuring are the two most important factors governing yield and quality, and in view of the differing requirements for malting and feeding it is important that the purpose of the crop shall be decided before it is sown. The introduction of new varieties in recent years has provided material with a high yield potential and at the same time their shorter and stiffer straws have made harvesting easier. Producers of feeding barley have been

tempted to grow these varieties under more fertile conditions or with more generous applications of nitrogenous fertilisers than was ever practicable with the older malting varieties. The result has been a considerable increase in yield and in an attempt to reduce lodging still further, reduced seed rates have been tried, frequently with success.

To shed some light on the interaction of seed rate and the time of application and quantities of nitrogenous fertilisers on barley for feeding purposes, trials were conducted at the School of Agriculture in 1956 and 1957 with the variety Herta. The trials were laid out in the form of a randomised block and the plots were sufficiently large to produce enough material for subsequent pig-feeding trials. Produce was harvested by combine and the following yields are expressed in cwts. per acre, corrected to a moisture content of 15%. In no case did serious lodging take place.

YIELDS IN RELATION TO SEED RATE AND NITROGENOUS FERTILISER TOP DRESSINGS

TABLE 1

SEED RATE	TREATMENT		Yield 1956 cwt/acre	Yield 1957 cwt/acre
	NITROGEN AT TILLERING (cwt. nitro-chalk per acre)	NITROGEN AT EAR EMERGENCE (cwt. nitro-chalk per acre)		
1½ bushels	nil	nil	32.2	25.7
1½ "	1	nil	34.6	28.6
1½ "	2	1	35.0	28.7
3 "	nil	nil	35.1	27.8
3 "	1	nil	36.9	29.3
3 "	2	1	38.1	30.6

RESPONSES TO NITROGENOUS FERTILISERS AND SEED RATES (PER ACRE)

TABLE 2

	High seed rate (3 bush)		Low seed rate (1½ bush)	
	1956 cwt./ac.	1957 cwt./ac.	1956 cwt./ac.	1957 cwt./ac.
Response to 1 cwt. nitro-chalk at tillering	1.8	1.5	2.4	2.9
Extra response to second cwt. nitro-chalk at tillering plus 1 cwt. at ear emergence	1.2	1.3	0.4	0.1
Total response to 2 cwt. nitro-chalk at tillering + 1 cwt. at ear emergence	3.0	2.8	2.8	3.0

	No nitrogen top dressing		1 cwt. nitro-chalk at tillering		2 cwt. nitro-chalk at tillering + 1 cwt. at ear emergence	
	1956 cwt./ac.	1957 cwt./ac.	1956 cwt./ac.	1957 cwt./ac.	1956 cwt./ac.	1957 cwt./ac.
Response to extra seed rate	2.9	2.1	2.3	0.7	3.1	1.9

In all cases there were responses to top dressings of nitrogenous fertilisers and to increased seed rates; but these responses varied considerably in magnitude. The highest response to a single top dressing of 1 cwt. nitro-chalk at tillering resulted from the lower seed rate but in this case the response to further applications of nitrogenous fertiliser was almost negligible. This suggests that the effects of a reduced plant population may be compensated only in part by applications of nitrogenous fertiliser, as at higher levels of application. the lower plant population in itself becomes the limiting factor. Crops sown at 3 bushels per acre consistently outyielded those sown at 1½ bushels per acre by an average of just over 2 cwts. of grain per acre,

Although counts showed almost twice the number of plants from the sowings at 3 bushels per acre, as from 1½ bushels per acre, which averaged 43.2 plants per foot length of drill, the crop densities, after tillering, evened out slightly owing to the higher tiller number per plant in the lower plant population. Shortly prior to harvest it was observed that the high seed rate, regardless of nitrogenous fertiliser treatment, resulted in plots which were very level and uniform in height, virtually all tillers having produced good ears. The lower seed rate produced crops with tillers of varying height, varying ear sizes and in varying stages of ripeness. The larger proportion of late-formed tillers and the variability in height of tillers gave an overall impression of a crop 2½ to 3 inches taller than in the case of the higher seed rate. Nitrogenous fertiliser had no measurable effect on this appearance.

Generally the seed rate appeared to have an influence on maturity and this effect of heavier seeding began to show as early as mid-June by the earlier senescence of the first-formed leaves, although to some extent this was delayed by the application of nitro-chalk at tillering. In neither year was mildew present.

In these trials, 1½ bushels of seed per acre, at comparable levels of nitrogenous fertiliser resulted in a reduced yield and a more uneven crop in respect of height and time of ripening than a seed rate of 3 bushels per acre. Both seed rates showed increased responses to increased quantities of nitrogenous fertiliser but it is doubtful whether the responses to the higher levels of application, particularly in the case of the low seed rates, were profitable.

The value of additional top dressings of nitrogenous fertilisers may, or may not, rest solely in the extra yield obtained, for in addition the increased content of nitrogen in the grain may have some extra value for livestock feeding. Work on this aspect is now proceeding.

THE SYSTEMATICS OF BUSH-HOPPERS

D. K. McE. Kevan

> ' "Of course they answer to their names?" the Gnat remarked carelessly. "I never knew them to do it . . " said Alice.'
>
> Through the Looking Glass.

Grasshoppers in Britain do not present a serious threat to agriculture and, although several species found in Britain are injurious elsewhere they are regarded here less with disfavour than with affection. In many other countries, however, these insects are a serious menace to crops and pastures. Locusts, for instance, are often very spectacular in their visitations and devastating in their effects: "The land is a garden of Eden before them, and behand them a desolate wilderness; yea and nothing shall escape them" (*Joel*, 2.3). Other species also cause comparable losses in a less dramatic manner over extended periods of time. Others again are of less general importance, but, nevertheless, significantly affect crops from time to time in limited localities; to these sporadic local pests belong a number which have been the subject of recent study at the School of Agriculture.

True (short-horned) grasshoppers belong to a large order of insects called Orthoptera, which include also crickets, bush crickets and their allies, and constitute one of its main divisions, the Acridoidea. The great majority of Acridoidea, including locusts and most other injurious species, belong to one large family, the Acrididae, which contains all the familiar British grasshoppers. In addition, the short-horned grasshoppers—so-called because of their comparatively short antennae—also embrace a number of smaller families, most members of which are not well described by the name 'grasshopper', since they prefer to live among vegetation rather than grass. The Pyrgomorphidae is one of these families, and it is to these that the names 'bush-locust' and 'bush-hopper' are given[1]. 'Bush-hopper' however, is a general term, like 'grasshopper', and is not strictly applicable to all species, many of which (including the two European ones) live among low vegetation; the term 'toad-hopper' has also been applied to *Chrotogonus*, a squat, warty, toad-like genus, which is largely confined to bare ground.

The great majority of Pyrgomorphidae are tropical or subtropical, and only a few extend into temperate latitudes. Few are pests of major importance, but several genera can cause quite severe local

destruction in various parts of the world. Amongst the most notable of these are *Colemania* and *Orthacris* in India, *Zonocerus* and *Phymateus* in various parts of Africa, *Sphenarium* in Mexico, *atractomorpha* in various parts of eastern Asia, Australasia and tropical Africa, and *Chrotogonus* in Africa and India. Many of these injurious forms occur in spasmodic outbreaks, but others are more insidious, biting off seedlings as they appear above ground. Tobacco is perhaps one of the most valuable crops to suffer in this way, although many bush-hoppers and bush-locusts are fairly catholic in their food preferences. Species of *Chrotogonus* also have the habit of descending into cracks in the ground and of burying themselves beneath the soil where many thus escape detection and consequently much of the blame for the damage they cause, Kevan[2] gives an account of the economic importance of this genus.

The classification of the larger genera of the Pyrgomorphidae—particularly *Chrotogonus, Atractomorpha, Orthacris, Taphronota* and *Pyrgomorpha* is now being reviewed. The taxonomy of these genera has been in an almost incredible state of confusion, making uncertain or impossible the identification of a large proportion of the species. This is turn has made it difficult to collate information on any particular species, because very frequently the names used have little or no real meaning. Current research, however, has now gone a considerable way towards rectifying the situation, and some results have been published; the synonymy of *Chrotogonus* has been given[3] and a full revision is in the press[4]; the revision of *Orthacris* has been partially completed with a review of its economic importance[5]; and a preliminary key and synonymy for *Atractomorpha* are nearly ready for publication.

In classical museum taxonomy, which must always remain the basis of all systematic work, a study of morphology is the fundamental tool. Some groups of animals are easy enough to separate into species by virtue of the existence of certain constant morphological characters. Many Pyrgomorphidae, however, are notorious for their variability and lack of such discrete morphological characters. The species are usually polymorphic—i.e. they differ in size, colour, general appearance, length of wings, and so on, so that any two individuals of a given species, examined in isolation, can appear to belong to entirely different species, although on the examination of further material, intermediates may be found which link up the two to form a continuous series belonging to a single species.

This variation, which may be very great in genera such as *Chrotogonus*, is often further complicated by the fact that different species

may overlap in their morphological characters, few of which are stable. Only by studying large series of specimens has it been possible to estimate which characters, **taken together,** may be used for identification. Clear cut differentiation on morphological grounds is seldom possible for species as a whole, for although some individuals may be easily separated, others are practically indistinguishable from those of other closely related species. This state of affairs is particularly true of the genera *Chrotogonus* and *Atractomorpha*. *Orthacris*, on the other hand, although requiring revision, presents fewer difficulties.

As an indication of the confusion which has existed in the past it may be noted that no fewer than forty-five nominal species were described or subsequently placed in *Chrotogonus*. In fact, after the removal of five species to other genera, the number which are valid appears to be only six, one of which has five, and two others, two subspecies each, making a total of twelve taxa (systematic units) only and three of these are new ! Much—one might be tempted to say almost all—that had been done by previous authors had to be undone before what is hoped is the true picture of the systemics of this genus emerged. Instead of having the almost random scatter of numerous so-called species in various parts of the world, *Chrotogonus* now agrees in its zoogeography with modern concepts applicable to others groups of animals.

Atractomorpha up to the present contained some 39 nominal species which current research has reduced to eight (with six additional subspecies). The present classisication is provisional and has not yet been published, but, as with *Chrotogonus* one might hope it will no longer be necessary, when asked if they "answer to their names", to reply "I new knew them to do it."

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SOME EFFECTS OF DIET IN CALF REARING

J. T. Morgan.

The prospect of reduced profit margins in cattle enterprises has stimulated considerable interest in economies that might be effected in the calfhood stage, when costs are disproportionately high in relation to the total period of growth. Unfortunately, the interpretation of available evidence on the effect of plane of nutrition in early life in relation to ultimate use, whether for beef or dairy production[1,2] is somewhat difficult to assess in commercial terms. There seems to be some virtue, in view of the variable dietaries used in calf rearing, in considering that growth rate response should be the criterion by which plane of nutrition should be defined and the success of the rearing methods evaluated.

The nature of the diet.

The recently evolved technique of early weaning to dry food in an attempt to reduce costs is based on the hypothesis that the rate of development of mature-type rumen digestion is a function of diet rather than of age. The application of this system thus offers the possibility of a new approach to feeding throughout the growth period of the animal.

Certain aspects of these diet/production relationships have been examined at the School of Agriculture using monozygotic twins. In the first instance three pairs of twins were used to compare the early wean system with the orthodox bucket rearing system on approximately equal total nutrient intake. The first group of calves were allowed 20 gallons of whole milk over a period of 4 weeks and a high quality concentrate (S.E. 74.3, P.E. 18.4) to a maximum of 4 lbs. per day. The second group were allowed 15 gallons of whole milk, $\frac{1}{2}$ cwt. proprietary milk substitute as a gruel, and a concentrate mixture (S.E. 68.1, P.E. 15.6) to a maximum of 3 lbs. per day—the liquid diet continuing for 10 weeks.

The following results were recorded over a period of 10 weeks :—

Method of Rearing	Early Wean System	Orthodox System
Av. Liveweight gain per day (lb.)	1.47	1.53
Food Consumption (lb. S.E.) :		
Hay and Concentrates	157.00	121.20
Milk and Milk Substitute	34.00	67.50
Lb. S.E./lb. Liveweight Gain	1.68	1.60

The liveweight gain obtained would be satisfactory for calves of dairy replacement type, but might be sub-optimal in beef production. These and other observations suggest that there should be some flexibility in implementing the early wean principle, in that success depends on reaching an adequate level of concentrate consumption before weaning actually takes place.

In spite of the relatively small differences in growth rate, morphological changes are manifest at three months in the rumen and reticulum and are illustrated in Plates 1—4. Rumen sections have been taken in all cases from the anterior wall of the ventral blind sac. Marked differences can be noted in the development of rumen papillae and the apparent compactness of the reticulum 'honeycomb'.

Two further groups of twin calves are being used to examine the long term implications of variations in the calfhood dietary. Management during the first three months has followed the patterns for those already described. From this stage bulk foods, including sugar beet pulp, kale and silage were introduced to the early wean group so that by six months the ration consisted entirely of roughages. The control group, on the other hand, was never allowed more than half the hay intake of the first, the remainder of the ration being composed of a high energy concentrate. Feed inputs were adjusted so that the calves made equal rates of gain.

The majority opinion[3] now seems to suggest that rumen development is not enhanced by roughage intake in the first three months of life. Plates 5 and 6, which show sections of rumen taken from a representative pair of calves slaughtered in the above experiment at nine months, suggest, however, that high roughage diet has perpetuated the differences resulting from ingestion of dry feed at earlier stages. Papillae development at nine months is superior in the early wean/high roughage calf in comparison with its mate.

The use of Antibiotics.

Numerous reports[4,5] lend support to the suggestion that some of the broad spectrum antibiotics, notably oxytetracycline (Terramycin) and chlortetracycline (Aureomycin) may be of value in promoting growth and wellbeing in young calves. 'Nutrition level' dosage appears to be of the order of 40 mg.—50 mg. per day.

A pilot observation was made on a local farm with a large beef enterprise, the system of rearing being orthodox bucket feeding. Twelve bull calves, including one pair of twins, were divided at ran-

dom into two groups, one acting as control while corresponding calves received a daily dosage of 40 mg. chlortetracycline. Over a period of twelve weeks the control calves gained an average of 1.45 lbs. per day, as compared with 1.65 lbs. per day for the supplemented animals. The inferior performance of the former group was mainly related to suboptimal growth of two calves which developed slight but persistent scours in the second week of the trial.

Several sets of monozygotic twins have been used for more critical observation to compare the effects of antibiotic administration at various dosage levels. Forty mg. per day appears to be an adequate 'nutritional' dose. Under circumstances of management which precluded the appearance of any clinical symptoms of disease, growth responses of the order of 10% have been obtained. A further interesting feature has been that at all dosage levels it has been found that reticulo-rumen volumes have increased by about 20%, and the dry weight of the small intestine reduced by 15%—20%. No adverse effects of the discontinuation of treatment after three months have been noted.

A further trial was undertaken at a time when conditions were conducive to the incidence of scours and mortality. Fourteen calves, the majority by the same sire and including two sets of dizygotic twins, were reared by the early wean system. 40 mg. of chlortetracycline were administered per calf per day to those animals comprising the treated group, whereas their counterparts acted as controls. One calf in this latter group died from scour.

The following results were recorded over a period of 12 weeks :—

	Antibiotic Supplement	Control	Treated Group as % Control
Av. Liveweight gain per day (lb.)	1.61	1.30	120
Food Consumption :			
Hay and Concentrates (lb. S.E.)	149.40	142.80	
Milk	34.00	34.00	
Lb. S.E./lb. Liveweight Gain	1.52	1.76	113
Number of Calves	7	6	

During this period two other unsupplemented calves died while their twin counterparts, receiving high level dosage of antibiotic remained healthy.

MORPHOLOGICAL CHANGES IN RETICULO-RUMEN IN RELATION TO DIET.

CALVES AT 3 MONTHS OF AGE

Plate 1. Rumen—'Dry Feeding'.

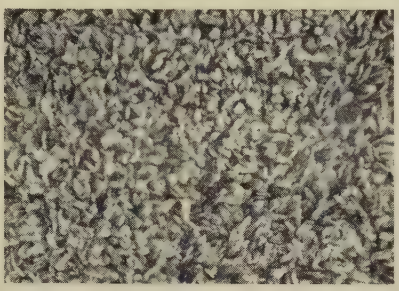

Plate 3. Rumen—'Gruel Feeding'.

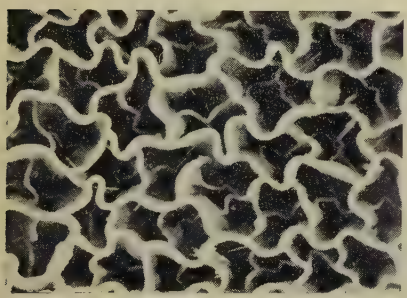

Plate 2. Reticulum—'Dry Feeding'.

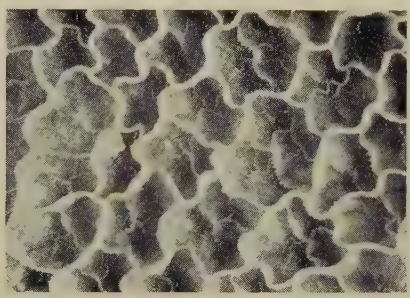

Plate 4. Reticulum—'Gruel Feeding'.

CALVES AT 9 MONTHS OF AGE

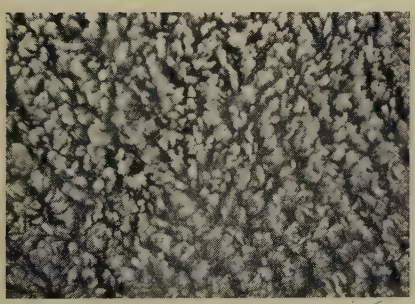

Plate 5. Rumen—'Dry Feeding' followed by 'High-Roughage'.

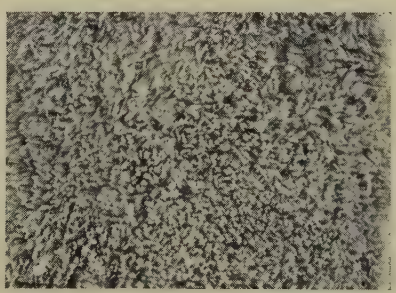

Plate 6. Rumen—'Gruel Feeding' followed by 'Low-Roughage/ High Concentrates'.

These preliminary results support the findings of other institutions that in some circumstances antibiotics can be of considerable value in reducing calf mortality, and can positively improve growth rate and the economy of food utilisation. Antibiotic resistant flora that result from continuous administration are on the whole favourable[5] and if a pathogen becomes established subsequent treatment with therapeutic doses of an alternative antibiotic will still be effective.

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THE WEATHER IN 1957.

T. Webster.

General.

This was a year in which unseasonable weather was as common as in 1956 and sometimes more extreme. Following a mild, wet winter and early spring, the next few months were very dry and not particularly warm. July, August and September were wet, dull and cool, and the remainder of the year, though drier and sunnier, had only average screen temperatures. While the annual means of rainfall, temperature, and sunshine were close to normal, wide monthly fluctuations were common, as in 1956, and in a number of ways the weather in the two years was very similar. The patterns of the fluctuations of monthly rainfall and sunshine about the average from March to October were remarkably similar, but there was a time lag of one month behind 1956 throughout this period. The general pattern of rain days per month during the two years was even more closely paralleled ; the similarity extended over the whole year. Of the extremes which occurred, March was the mildest recorded in Britain this century, while in England and Wales April was the driest since 1938 and September the wettest since 1950.

Rainfall.

February was very wet, with almost double the normal rainfall, but even this had been exceeded twice in the previous twelve years. Seven inches of snow fell on the night of the 18-19th February, the only appreciable fall of the winter, but it lay for only a week.

The July rainfall, though only 25% above normal, had been exceeded only once in the previous twelve years. The July rain days were the highest, and the highest above average, of any month. The really exceptional rainfall was the 5.57 inches in September, almost four times the normal amount. This was however largely due to a few days very heavy rain ; rain days in the month were not excessive. A long spell of dry weather began in April, and was not really broken until July. The relatively dry weather in the last three months of the year was accentuated by the low number of rain days in November, almost as low as in April.

Sunshine.

February, December and particularly June were very sunny, but there was a long period of relatively dull weather from July to October. There had been no brighter June or duller July in the previous twelve years.

Radiation.

In addition to the duration of sunshine, the total amount of radiant energy received per day is now being measured by means of a Kipp thermophile. Records of the daily radiation have been kept over most of the growing season, and in future these will be available over a longer period.

Temperature.

All the mean temperatures recorded were above average for the first four months of the year. March was especially warm, with a mean air temperature over 5°F above normal. An exceptionally low air minimum temperature of 3°F was recorded on 20th February, but soil and grass minimum temperatures remained above freezing because of snow cover. May was very cold. Grass minimum temperatures of 17°F and 18°F were recorded during the first eight days, while during the whole month there were seventeen ground frosts. Fluctuations during the remainder of the year were smaller but only June and October had above average air temperatures, September being the coldest month. Soil temperature fluctuations were similar, the high figures recorded early in the year being particularly notable.

Crops.

Because of the very mild winter and early spring, no frost damage was done to autumn sown crops. Snow cover saved field crops from the very severe air frost on 20th February, which caused considerable damage to exposed evergreen hedges and shrubs and to those trees which had broken bud very early in the unseasonably mild weather.

Field conditions in spring were only moderate, but even crops sown in good time suffered considerably in the early summer drought. Slow and patchy emergence of potatoes and partial failures of beet were common. The frosts in May did some damage to potatoes, but the obvious effect was less than in the previous year. Despite some wilting in June, beet and potato crops remained remarkably vigorous, but following the rain in July there was an appreciable amount of second growth in potatoes. Heavy aphis infestation was found on most crops, and potato viruses and sugar beet yellows were widespread. Mildew on cereals was moderate, and there was more yellow rust than usual, though the general infection was rather late and not serious. Potato blight appeared in the middle of August and spread fairly rapidly.

Good cereal harvesting conditions were infrequent and all the combined grain required drying. Winter wheat yields were good, but spring cereals, especially oats and wheat, were disappointing. Heavy shedding losses occurred in crops still standing on 25th August when there were winds of force 8. Potato yields were good, though often with a high proportion of seed-size tubers, but there was considerable blight and second growth. Mangels and sugar beet were harvested under good conditions, the yields, dry matter and sugar contents being good despite the unpromising weather.

Sowing conditions for winter cereals were excellent, and locally many early sown crops made a good establishment although rather low soil temperatures prevailed.

WEATHER DATA FOR 1957.

	JAN.	FEB.	MARCH	APRIL	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	YEAR
A. Rainfall (inches)	1.53	2.76	1.55	0.20	0.84	1.30	2.71	2.23	5.57	0.98	2.04	1.46	23.17
Rainfall as % of average 1885—1915	93	199	107	14	48	74	125	99	371	42	110	66	107
No. of times rainfall exceeded in previous twelve years	6	2	5	12	11	10	1	7	0	9	4	10	7
No. of rain days	17	15	13	6	12	11	20	17	19	11	8	14	163
Rain days as % average 1946-1957	118	112	102	54	93	81	167	121	136	94	55	94	102
B. Total sunshine (hours)	46.9	76.3	89.3	129.5	187.3	264.0	116.0	116.1	100.1	76.8	58.9	48.4	1309.6
Sunshine as % of average 1921—1950	114	129	83	93	106	139	64	72	81	80	110	151	96
No. of times sunshine exceeded in previous twelve years	2	1	7	11	4	0	12	10	10	9	3	2	8
C. Mean daily radiation ($g.\ cal.\ cm^{-2}\ day^{-1}$)	—	—	—	—	396.8	492.0	322.5	262.0	192.2	—	—	—	—
D. Temperature (°F)													
(1) Mean screen maximum	47.1	46.5	54.8	55.4	59.0	70.4	68.7	67.0	60.7	57.6	47.7	44.9	56.6
(2) Mean screen minimum	35.7	33.2	40.2	38.5	39.5	46.9	53.6	51.2	47.2	43.2	38.1	33.4	41.7
(3) Average of (1) and (2)	41.4	39.9	47.5	46.9	49.3	58.7	61.1	59.1	53.9	50.4	42.9	39.1	49.2
(4) Deviation from average 1921—1950	+ 3.0	+ 1.0	+ 5.3	+ 0.2	− 2.7	+ 1.1	− 0.5	− 1.4	− 2.4	+ 0.8	− 0.1	− 0.3	+ 0.3
(5) Soil temperature at 4"	39.2	38.5	44.0	46.1	51.6	60.3	61.6	59.2	53.1	48.7	41.6	38.2	48.5
(6) Deviation from average 1946—1957	+ 1.8	+ 1.9	+ 4.6	+ 0.9	− 0.4	+ 2.2	+ 0.1	− 0.7	− 2.4	− 0.4	− 1.6	− 1.2	+ 0.4
(7) Soil temperature at 8"	40.3	39.9	44.6	46.4	51.1	58.6	60.8	59.3	54.0	50.1	43.5	39.7	49.0
(8) Deviation from average 1946—1957	+ 1.9	+ 2.2	+ 4.4	+ 1.1	− 0.4	+ 1.5	+ 0.1	− 0.6	− 2.3	− 0.1	− 0.9	− 0.9	+ 0.5
(9) Soil temperature at 2'	42.0	42.0	44.8	47.1	50.3	56.4	60.2	59.9	56.6	52.8	47.6	43.1	50.2
(10) Deviation from average 1946—1957	+ 1.7	+ 2.7	+ 3.3	+ 0.7	− 1.4	− 0.9	− 0.9	− 1.2	− 1.6	Nil	+ 0.5	+ 0.4	+ 0.2

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P. J. SALTER

The effects of different water-regimes on the growth of plants under glass, III : Further experiments with tomatoes (*Lycopersicum esculentum* Mill.). *J. hort. Sci.*, **32 :** 214-26. (1957).

LECTURES AND PAPERS GIVEN BY MEMBERS OF THE STAFF IN 1956

A. BROOME :

'The Use of Hormones in Meat Production' to National Agricultural Advisory Service Conference at Spilsby.

D. V. CRAWFORD :

'Microbiological Aspects of Podzolization', to the 6th Congress of Soil Science at Paris.

WINIFRED M. DULLFORCE :

Discussion on the B.B.C. horticultural programme.

M. M. EDWARDS :

'The Occurrence and Mode of Action of an Inhibitor in the Seeds of Sinapis Arvensis L.', to the Society for Experimental Biology at London.

E. G. HALLSWORTH, J. AUDEN and E. A. GREENWOOD :

'Some Nutrient Interactions Affecting the Growth of Pasture Legumes in Acid Soils', to the Society of Chemical Industry, Trace Elements in Agriculture Symposium at Bristol.

W. HEYDECKER :

'Technical Aspects of Seed Sowing', to the Derby Horticultural Discussion Group.

J. P. HUDSON ;

'The Study of Plant Responses to Soil Moisture', to the Fourth Easter School in Agricultural Science at Sutton Bonington.

'The pC Concept in Tomato Production', to the Glasshouse Group of the National Agricultural Advisory Service at London.

'Plants and their Water Relationships', to the Reading University Horticultural Club.

'Control of Environment in Biological Work', to the Biological Society at Nottingham.

'Physiological Aspects of Mist Propagation', to the East Midlands Horticultural Conference at Sutton Bonington.

'Recent Work at Sutton Bonington', to the Leicester Horticultural Discussion Group.

'The Effects of Daylength on Plant Growth', to the Vaughan Horticultural Society at Leicester.

'An Analysis of the Nation's Food Supplies', to the Nottingham Society of Engineers.

Discussions on the B.B.C. horticultural programmes.

J. D. IVINS :

'Cereal Production', to the Farnsfield Farmers' Discussion Group.

'Controversial Aspects of Grassland Management', to Students of Shuttleworth Agricultural College.

'Maximum Profit from Grassland', to Ashover Farmers' Club.

'The Principles of Strip Grazing', to Leicestershire Farm Institute Old Students Association at Brooksby.

'Modern Techniques in Crop Production', to Leicestershire Farm Institute at Brooksby.

'Crop Production and Utilization', to Electrical Development Association Rural Electrification Conference at Sutton Bonington.

'British Agriculture', to Derby Junior Chamber of Commerce.

'Ecology of Grassland', to Shepshed Rotary Club.

Forum—Institute of British Agricultural Engineers at Kesteven Farm Institute, Caythorpe.

J. D. IVINS, G. E. LAMMING and K. RASMUSSEN :

'Economic Milk Production', to the Ayrshire Cattle Breeders' Club at Southwell.

D. K. McE. KEVAN :

'Orthoptera and their Allies', to the Derbyshire Entomological Society.

'Soil Animals', to the Leicester Literary and Philosophical Society. (Zoological Section).

'Invertebrates Underground', to the Nottingham Natural Sciences Field Club.

'Education and Training in Plant Protection at British Universities', to the Annual General Meeting of the Vereinigung Deutscher Pflanzenartze at Hamburg.

G. E. LAMMING ;

'Recent Research in Animal Husbandry', to the N.A.A.S. Conference at Sutton Bonington.

'Breeding Problems in Cattle, Sheep and Pigs', to N.A.A.S. Meetings at Alford and Brigg, Lincs.

'The Use of Hormones in Meat Production' to Nottinghamshire Farm Institute Old Students' Refresher Course at Brackenhurst.

'Breeding Problems in Cattle and Sheep', to Edenham Discussion Society.

'How to Improve the Fertility of Farm Animals', to Ashover Farmers' Club.

'The Use of Hormones in Animal Production', to Biological Society, University of Nottingham.

'The Effect of Hexoestrol and Stilboestrol on the Growth of Cattle and Sheep', to the Nutrition Society at London.

'Fertility and Infertility', to British Veterinary Association, East Midlands Division at Sutton Bonington (with Mr. L. E. A. Rowson).

'The Effect of Hormones on Growth Rate and Carcase Quality', to Institute of Corn and Agricultural Merchants, Leicestershire Farm Institute at Brooksby.

'The Use of Hormones in Beef Production ', to N.A.A.S. Conference, Market Rasen, to a class organised by Yorkshire Education Authority at Howden, on B.B.C. Farm Fare programme and B.B.C. Television Farming programme.

'The Treatment of Anoestrum', to Society of Animal Breeding at London.

N. McDERMOTT :

'Seed Potato Production', to Brecon and Radnor Seed Growers' Association at Builth Wells.

'Seed Potato Production', to Isle of Man Conference of Farmers.

'Potato Varieties', to Leicestershire Horticultural Judges Guild at Leicester.

'Modern Trends in Potato Varieties', to Nottinghamshire Potato Growers at Retford.

F. L. MILTHORPE :

'The Influence of Light and Night Temperature on Leaf Growth', to the Society for Experimental Biology at London.

'The Influence of Weather on Plant Growth', to the Derby Scientific Society.

J. T. MORGAN :

'Modern Techniques in Livestock Production', to Leicestershire Farm Institute at Brooksby.

'Potatoes for Stockfeeding', to National Association of Seed Potato Merchants at Sutton Bonington.

'The Work of the School of Agriculture', to Long Eaton Rotary Club.

'The Environmental Requirements of Livestock', to the Royal Institution of Chartered Surveyors at Sutton Bonington.

'Crop Production and Utilization', to the Electrical Development Association Rural Electrification Conference at Sutton Bonington.

'Use of Antibiotics, Hormones and Trace Minerals in Pig Production' to Conference of Pig Producers, Kesteven Farm Institute, at Caythorpe.

'Quality Bacon and Its Profitable Production', to Conference of Pig Producers at Dunmow.

K. RASMUSSEN :

'Economics of Farm Buildings', to the Royal Institution of Chartered Surveyors at Sutton Bonington.

H. A. ROBERTSON and A. W. J. BROOME :

'Some Effects of Thyroxine on Copper Metabolism in Animals', to the Society of Chemical Industry, Trace Elements in Agriculture Symposium at Bristol.

R. SHORTHOSE :

'The Use of Hormones in Meat Production', to the Stalham Farmers' Club.

I. H. WILLIAMS :

'The Influence of Environmental Factors upon the Biennial Habit of the Raspberry Shoot', to the Society for Experimental Biology at London.

'Light and Temperature as Factors in the Growth and Development of the Raspberry', to the Association of Applied Biologists at London.

'The Influence of Environmental Factors upon the Flowering Habit of the Raspberry Shoot', to the Society for Experimental Biology at Cambridge.

M. WOODBINE :

'The Training of Microbiologists : The "Common-stem" Course', to a Joint Meeting of the Society of Chemical Industry (Microbiology Group) and Society of Applied Bacteriology at London.

TITLES OF THESES ADMITTED FOR HIGHER DEGREES IN THE FACULTY OF AGRICULTURE AND HORTICULTURE 1949-1957.

AGRICULTURAL SCIENCES.

1952 FARIED, A.
A study of the bacterial flora of the ovine repiratory tract. **Ph.D.**

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The bacteriology of bovine mastitis in the East Midlands. **Ph.D.**

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The relationships between lactic acid, calcium and phosphorus in milk, whey and rennet curd. **M.Sc.**

SEAMAN, A.
The antibacterial mechanism of trypanocidal drugs. **Ph.D.**

1955 CHISLETT, M. E.
The microbiology of podzolic soils with particular reference to iron depositing bacteria. **Ph.D.**

LAHIRI, R.
Pedogenesis in the East Midlands (Nottinghamshire). **Ph.D.**

NICOLSON, T. H.
The mycotrophic habit in grasses . . . **Ph.D.**

TAYLOR, C. E.
Aphids infesting potato crops—with special reference to the influence of plant growth on population dynamics. **Ph.D.**

1956 COATES, J. I.
Studies on the growth and structure of the alimentary tract of the fowl, the goose and the ruminant. **Ph.D.**

KEVAN, D. K. McE.
The Chrotogonini : a critical revisional study of the injurious. Pyrgomorphine Acridid, genus *Chrotogonus* and its allies (Insecta : Orthoptera). 2 vols. **Ph.D.**

LOMAS, D.
Preliminaries to a study of the black aphids of the genus *Aphis*, L. **M.Sc.**

McKEE, R. K.
Studies on the toxicity of solanine and related compounds to micro-organisms and on the influence of solanine content on the resistance of potato tuber tissues to fungal infection. **Ph.D.**

SINGH, M. P.
Studies in the bionomics of three common British species of cutworm (Lepidoptera : Phalaenidae). **M.Sc.**

WHITTINGTON, W. J.
A study of the rôle of boron in the nutrition of certain legumes. **Ph.D.**

1957 AHMAD, N.
A pedological study of the soils of the University Farm with reference to the development of morphological features associated with impeded drainage. **Ph.D.**

ASPINALL, D.
An analysis of the competition between barley and white persicaria. **Ph.D.**

SUTTON, C. D.
A study of some effects of soil acidity on the growth of certain members of the leguminosae. **Ph.D.**

WIX, P.
Micological synthesis of fat from whey : the utilization of whey by moulds with a view to potential fat production. **Ph.D.**

AGRICULTURE.

1951 IVINS, J. D.
The relative palatability of certain strains and species of herbage plants. **M.Sc.**

1952 STEARN, E. F. R.
Some factors affecting the efficiency of dairy cattle in converting their food into milk. **M.Sc.**

1953 MORGAN, J. T.
An analysis of some factors affecting brood sow and weaner performance. **Ph.D.**

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The role of white clover in grassland. **M.Sc.**

IVINS, J. D.
Some aspects of pasture evaluation with particular reference to the measurement of pasture productivity on a farm scale. **Ph.D.**

1955 MANNERS, M. J.
The effects of environmental factors on growth in pigs. **M.Sc.**

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Bovine infertility associated with Vibrio foetus infection. **M.Sc.**

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The effect of hormones on the growth rate and carcase quality of beef cattle and lambs. **Ph.D.**

MONTAGUE, V. J.
A study on some factors affecting growth, development and yield in the potato crop. **M.Sc.**

1956 WEBSTER, T.
A study of factors affecting yield and dry matter content of mangels and fodder beet. **M.Sc.**

1957 CHATTERTON, J.
A multi-purpose crop drier for the small farm. **M.Sc.**

HORTICULTURE.

1953 MARSTON, M. E.
The history of plant propagation in England to 1850. **M.Sc.**

SALTER, P. J.
Cultural practices affecting root development of crops under glass, with special reference to the effects of different Water regimes on tomatoes. **M.Sc.**

1954 HEYDECKER, W.
Cultural factors influencing the germination of vegetable seeds. **M.Sc.**

HUDSON, J. P.
Factors affecting the regeneration of plants from roots. **Ph.D.**

1955 FISHER, D. E.
The growth of plants in containers with special reference to the effects of different water-regimes. **M.Sc.**

WILLIAMS, I. H.
Aspects of the regeneration of plants from root cuttings with special reference to the effect of environment upon the aerial growth from raspberry root cuttings. **M.Sc.**

1956 DULLFORCE, W. M.
Studies on the growth of transplanted seedlings in relation to the effects of injury and environmental factors. **M.Sc.**

MAJMUDAR, A. M.
A study of the relationships between soil moisture tension and growth rate (with special reference to the effects of different water-regimes on growth under glass). **Ph.D.**

SALTER, P. J.
Further studies on the water relations of the tomato (Lycopersicum esculentum Mill.) **Ph.D.**

1957 CLAY, D. W. T.
The water relationships of plants grown under glass with special reference to the effects of soil salinity on growth of the tomato. **M.Sc.**

WILLIAMS, I. H.
The influence of environmental factors upon the growth and development of the red raspberry. **Ph.D.**

AGRICULTURAL ECONOMICS.

1949 EVANS, D. H.
The development of farm mechanisation in England and Wales. **M.Sc.**

1950 MEJER, E.
Agricultural labour in England and Wales, 1917-1939. **M.Sc.**

1953 DEXTER, K.
The economic position of the horse in British agriculture. **Ph.D.**

1956 BIRD, A. R.
Some effects of government support to agriculture and the motor industry in the United Kingdom. **M.Sc.**

1957 WARLEY, T. K.
Some economic aspects of labour use in the farm-scale production of vining peas and autumn cauliflowers. **M.Sc.**

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Profits from Arable Sheep Flocks, (F.R. No. 118). 2s. 0d.

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The Pattern of Farming in the East Midlands. (1954). 6s. 0d. JONES R. BENNETT.

Sheep in Lincolnshire 1953-54. (F.R. No. 129) (1955). 1s. 6d. WOOD, R. OWEN.

Cost of Growing Barley and Wheat in 1954. (F.R. No. 130). (1955). 1s. 6d. SANDILANDS, MARGARET. M.

Economics of Grain Drying and Storage. (F.R. No. 131). (1955). 2s. 0d. THEOPHILUS, T. W. D.

Farming Types and Financial Results 1954-55. (F.R. No. 132). (1955). 2s. 0d. MORTIMER, R. G.

The Profitibility of Grass Fattened Cattle 1953-54. (F.R. No. 133). (1955). 2s. 0d. RICHARDSON, PRUDENCE P.

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The Costs of Rearing Single Suckled Calves. (F.R. No. 137). (1956). 2s. 0d. BROWN, A.

Farming Types and Financial Results 1955-56. (F.R. No. 138). (1956). 2s. 0d. HUNT, R. W. T.

Farming Types and Financial Results 1956-57. (F.R. No. 139). (1957). 2s. 0d. HUNT, R. W. T.

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Water-regimes in Irrigation Research. (Reprinted from the Report of the 14th International Horticultural Congress, Netherlands, 1957). 1s. 0d. HUDSON, J. P. SALTER, P. J., and MAJMUDAR, A. M.

Plants and their Water Supplies. (Reprinted from Endeavour, **16**, 84-9, 1957). 1s. 0d. HUDSON, J. P.

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Soil Zoology. Proceedings of the Second Easter School in Agricultural Science, University of Nottingham 1955. Editor : D. Keith McE. Kevan. Publishers : Butterworths Scientific Publications, London, 1955. Price 55s. 0d.

The Growth of Leaves. Proceedings of the Third Easter School in Agricultural Science, University of Nottingham 1956. Editor : F. L. Milthorpe. Publishers : Butterworths Scientific Publications, London, 1956. Price 40s. 0d.

Control of the Plant Environment. Proceedings of the Fourth Easter School in Agricultural Science, University of Nottingham 1957. Editor : J. P. Hudson. Publishers : Butterworths Scientific Publications, London, 1957. Price 42s. 0d.

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